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Two Years Results with Codling Moth Sprays[1]

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The Purdue orchard at Bedford contains about 70 acres of mature apple trees. This orchard is located in the three-brood codling-moth belt of Indiana where a combined attack of late second-brood and third-brood worms has been very difficult to control from August 10 to harvest. With some spray schedules used in the past the orchard has produced less than 50 per cent fruit free of codling-moth injury.

In 1937 a partly isolated block of 15 acres in this orchard was sprayed with a common commercially prepared brand of nicotine-bentonite combined with one-half per cent summer oil beginning with the second cover spray. Six nicotine sprays were applied—four against the first brood and two in July against second brood (last spray date was July 24). In spite of a heavy codling-moth population at the start of the 1937 season control was satisfactory in the nicotine area until about August 10, but from this date on a heavy codling-moth attack occurred which resulted in almost 20 per cent wormy fruit at harvest. In 1938 the same materials were used on the same area of the Bedford orchard but eight nicotine cover sprays were used compared to six in 1937, with the last application made August 11, 18 days later than in the previous year. On July 26, or at the time of the seventh nicotine cover spray in 1938, 14 trees in the 15-acre nicotine-sprayed block received 6 pounds of lead arsenate and one quart of summer oil in $\frac{3}{4}$–$1\frac{1}{2}$–100 bordeaux. The same 14-tree area was re-sprayed on August 11, using 4 pounds of lead arsenate and one quart of summer oil in $\frac{3}{4}$–$1\frac{1}{2}$–100 bordeaux. In addition, 14 more winesap trees received 6 pounds of lead arsenate and one quart of summer oil in $\frac{3}{4}$–$1\frac{1}{2}$–100 bordeaux in place of the last regular nicotine-bentonite-oil spray used on the rest of the 15-acre block.

All of the material in the large plot treatments (Plots 1 and 2) was applied with stationary spray equipment and by the regular farm crew. Plots 3 and 4 were sprayed with a portable rig and by one of the farm crew.

It has been shown that lead arsenate is especially effective against codling moth in the middle and later part of the growing season (Steiner *et al.* 1939), but it was believed that lead and arsenic residues from such late applications might be difficult to remove by standard washing procedure. It was the idea of these tests to determine the lead and arsenic loads that might result from one and two sprays applied in July and early August when preceded by a spray program of nicotine-bentonite-oil and also to compare the ease of washing of such fruit with that from plots given only a heavy first-brood schedule of lead-oil. Following these treatments codling-moth infestation records were taken and foliage injury compared with that in the all-season nicotine and heavy first-brood lead-oil-sprayed areas.

Table 1 gives the micrograms of arsenic per square inch of apple surface and the fruits per pound when sampled. It required four cover sprays and two "top-offs" of lead arsenate on plot 1 to build up an arsenic coverage by June 2 of 166 micrograms per square inch of apple surface, while the one lead-oil spray on plot 3 applied July 26 is mainly responsible for a coverage of 122 micrograms of

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Table 1.—Micrograms of arsenic per square inch of apple surface. (1938 Results).

Plot	When Sampled	Date	Micrograms as per Sq. In.	Apples per Lb.
1*	Before 4th cover	6/ 2/38	62	29.3
1	After 4th cover	6/ 2/38	166	29.3
1	54 days after 4th cover	7/26/38	28	5.5
3*	After 8th cover	7/26/38	122	5.5
3	After 9th cover	8/11/38	170	4.0
4*	After 9th cover	8/11/38	164	4.0

* *Plot Spray Schedules. Plot 1*—Calyx, calyx top-off and first cover with lead arsenate followed by three covers and an extra top-off of lead-oil with 4th and last cover June 2. *Plot 2*—same as plot 1 up to 2nd cover, then eight covers commercial nicotine-bentonite plus one-half per cent summer oil. *Plot 3*—same as plot 2 up to 7th nicotine spray then 6 pounds lead arsenate plus 1 quart of summer oil in ¾-1½-100 bordeaux and 4 pounds lead arsenate and 1 quart summer oil in ¾-1½-100 bordeaux applied at time of 8th nicotine spray on plot 2. *Plot 4*—same as plot 2 up to 8th nicotine spray, then one cover of 6 pounds lead arsenate and 1 quart of summer oil in ¾-1½-100 bordeaux.

arsenic and this was increased to 170 by a second lead-oil spray on August 11. The heavy arsenic load on plot 4 is also of special interest when compared with the coverage on plot 1.

A combined attack of late second-brood and third-brood worms began about August 8 in this orchard in 1938, and the high arsenic film on the surface of the fruit which was obtained by a single lead-arsenate spray, on plots 3 and 4, seems to indicate that one application would have been sufficient to control late-season codling moth. This prediction is further strengthened by the results secured in 1939 from a single lead-oil-soap spray on July 17 (Table 4, plot 2B).

Table 2.—Relative effectiveness of the various plot treatments in 1938 as shown by harvest infestation counts.

Plot	Variety	Number Fruits Examined	One or More Worms Per Cent	One or More Stings Per Cent
1*	Winesap	2980	4.2	6.8
2	Winesap	2308	4.6	5.5
3	Winesap	2060	.9	4.9
4	Winesap	2160	2.1	6.0

* See plot spray schedules under Table 1.

Note: The record of scored fruit at harvest shows no difference in the effectiveness of the lead arsenate and nicotine treatments in plots 1 and 2, but the fact that there was a carry-over from 1937 of about 15 times as many larvae in the plot 2, 3 and 4 area, as compared with the 55 acres covered by the lead arsenate-oil treatment in plot 1, may have had a very important bearing on 1938 results. The substitution of either one or two cover sprays of lead arsenate for three sprays of nicotine-bentonite-oil during July and early August only slightly reduced harvest infestation in plots 3 and 4 as compared to that in the plot 1 and 2 treatments.

COMPARATIVE CONTROL.—Table 2 gives a harvest record of the amount of codling-moth injury in the four plots at harvest in 1938. No unsprayed trees are left in this orchard. Harvest records on plots 1 and 2 were obtained partly by removing three fruits at random from all crates of picks and drops from the entire plot and partly from scoring the picks and drops from sectors of representative trees. Records for plots 3 and 4 were obtained entirely by scoring sectors of representative trees including picks and drops at harvest.

RESIDUES AND WASHING RESULTS.—All fruit for residue analysis and washing studies was selected from the lower outside area of the tree and was put over a standard apple sizer. All samples were

Table 3.—Arsenic and lead residue at time of harvest and after washing—1938.

Plot	Gr As. per Lb.	Gr. Lead per Lb.	Washed in 2½% HCL for 20 Sec. @ 63°†		Washed in 1½% HCL for 20 Sec. @ 100°†	
Number	Before	Before	As.	Lead	As.	Lead
1*	.055	.111	.014	.019	.010	.020
2	.012	.022	not washed		not washed	
3	.077	.198	.011	.024	.010	.017
4	.046	.188	.011	.030	.006	.017

* See spray schedules by plot under Table 1.

† Underbrush-flood type washer.

Note: The arsenic load on plot 1 (heavy first brood lead arsenate schedule) seemed slightly more resistant to cleaning by the washing treatment at packing shed temperatures. The residues on plots 3 and 4 were cleaned almost to the tolerances without heat and show a high percentage lead removal, probably because the residue was not as heavily concentrated in the stem and calyx ends of the fruit as was the case on the fruit from plot 1.

then taken from the $2\frac{1}{2}$ to $2\frac{3}{4}$ inch bin. All samples were washed on the day of picking. The analysis on unwashed samples represents the average of four separate determinations, while the residue figures for washed samples are the average of two separate determinations.

It has been found in all our past work with underbrush-flood type washers that a high residue removal can be obtained with $2\frac{1}{4}$ per cent hydrochloric acid at packing shed temperatures and that very little increased removal results when the temperature is increased to 100 degrees F. (Table 3).

1939 RESULTS.—In the spring of 1939 the overwintering population of codling moth should have been much more uniform throughout the 70-acre Bedford orchard than was the case at the start

of the 1938 season, as the plot treatments in 1938 covered the entire orchard and control was very good regardless of the spray program used.

Plot Layout.—The same 55-acre area received only a first-brood lead-oil spray treatment as in 1938 and the original 15-acre nicotine block was again given over to a seasonal program of factory-mixed nicotine-bentonite to which summer oil was added. The same farm spray crew made all spray applications.

Spray Program.—The 55-acre lead-oil area received a calyx and 3 covers at 6 pounds lead arsenate and one-half-gallon oil in $\frac{3}{4}$–$1\frac{1}{2}$–100 bordeaux. These two small plots received no further spraying the rest of the season.

Harvest Infestation Counts.—According to G. E. Marshall of the Purdue Entomology Division, mature second-brood moths were found in this area on July 1 and third-brood moths on August 11, followed by a heavy third-brood attack August 25 to 31. September was very favorable for codling-moth development with a number of days at or above 100 degrees, and with the first killing frost on

Table 4.—Relative effectiveness of the various plot treatments in 1939 as shown by harvest infestation counts.

Plot*	Variety	Type of Sample	Fruits Exam.	One or More Worms	One or More Stings
			Number	Per cent	Per cent
1*	Grimes	Harvest picks and drops	2583	0.3	0.5
1	Grimes	2 fruits each crate picks	6340	0.3	0.5
1	Winesap	Harvest picks and drops	6239	1.6	3.0
1	Winesap	2 fruits each crate picks and drops	1539	2.0	4.0
2	Grimes	Harvest picks and drops	2357	4.8	2.2
2	Grimes	3 fruits each crate picks	1693	3.0	2.8
2	Winesap	Harvest picks and drops	5248	5.6	2.6
2A	Winesap	Harvest picks and drops	4702	12.0	4.0
2B	Grimes	Harvest picks and drops	4289	1.2	2.9
2B	Winesap	Harvest picks and drops	4211	0.7	2.2
2C	Winesap	Harvest picks and drops	8434	1.7	3.4

* *Spray treatments, 1939.*—All plots received lead arsenate in the calyx and in 1st cover had 4# lead arsenate plus 1 pint oil. *Plot 1*—2nd cover, lead-oil-soap; 3rd cover, lead-oil-bordeaux; 4th cover, lead-oil-soap top-off on June 13. *Plot 2*—2nd, 3rd, 4th, 5th, first brood covers of 5# factory mix nicotine-bentonite plus 3/5 gal. summer oil and 6th and 7th covers 4# nicotine-bentonite plus ½ gal. oil—last spray August 1. *Plot 2A*—same as plot 2 except that the 6th cover was omitted. *Plot 2B*—same as plot 2 except that lead-oil-soap was applied July 17 in place of the 5th and 6th nicotine covers as used on plot 2. *Plot 2C*—same as plot 2 except that 6# lead arsenate, ½ gal. oil in weak bordeaux was used on July 17 in place of the 5th and 6th nicotine covers applied on plot 2.

seven-day intervals and at the time of the fourth cover only the top half of the trees was sprayed (plot 1). The nicotine area had the standard calyx and first cover of lead arsenate followed by four more first-brood covers of nicotine-bentonite-oil at approximately seven-day intervals and two second-brood covers on July 17 and August 1 (Plot 2). This was the same number of sprays applied in 1936 which gave very poor control but against a much greater overwintering codling-moth population. On July 17 fourteen trees in the nicotine area received a spray of 4 pounds of lead arsenate, ½ pound soap and one-half gallon oil (Plot 2B) and another area of 14 trees was sprayed with

October 1. Grimes plots were harvested September 7 to 10 and Winesap plots on September 26 to 30.

Table 4 gives the harvest infestation records by plot. As in 1938 two methods were used in scoring fruit from the large-plot areas, first, entire trees of picks and drops, and second, a random sample taken from each lug box and representing all the fruit from the plot as it was brought to the packing house. Both the large-area nicotine and lead plots show good commercial codling-moth control (Plots 1 and 2). Plot 2A, on which the 6th cover of nicotine materials was omitted on July 17, shows a definite increase in wormy fruit. Plots 2B and 2C, which

received one lead-arsenate spray on July 17 in place of the two regular nicotine sprays of July 17 and August 1, show practically as good control as that in plots 1 or 2 and is in accord with the control figures for 1938 (Table 2).

Harvest Spray Residue and Washing Results.—Fruit from the plot 1 area, which received only a first-brood lead-arsenate schedule consisting of a calyx, three covers and a top-off, carried low-harvest lead and arsenic loads that were easily and rapidly washed to well below

sprays have been applied severe foliage injury and varying amounts of fruit russet and reduction in fruit size has commonly occurred.

In 1938 slight foliage injury appeared in both the large-plot nicotine- and lead-sprayed areas in late July, but in neither case was the damage severe even in late August. Plot 3 which received two heavy-lead-oil-Bordeaux sprays on July 24 and August 10 following five applications of nicotine-bentonite-oil gave no evidence of injury on Winesap fruit or foliage.

Table 5.—Arsenic and lead residues at time of harvest and after washing—1939.

		Before Washing		Washed in 2¼% HCl for 20 sec. @ 76°†	
Plot*	Variety	Grs. As.—1*	Gr. Lead—1*	Gr. As.—1*	Gr. Lead—1*
1*	Grimes	.0179	.0597	.0024	.0106
1	Winesap	.0226	.0414	.0031	.0094
2	Grimes	.0057	.0173	Not washed	
2	Winesap	.0102	.0196		
2B	Grimes	.0421	.0901	.0043	.0180
2B	Winesap	.0390	.0830	.0090	.0238
2C	Winesap	.0422	.0800	.0090	.0088

* See spray schedules by plot under Table 4.
† Underbrush-flood type washer.

present tolerances. Grimes averaged 6.6 and Winesap 9.6 fruits per pound when the July 17 lead spray was applied to plots 2B and 2C. Because of the advanced stage of growth this resulted in moderately high residue loads at harvest, but, as in 1938, a high-percentage removal was obtained by the washing treatment at packing shed temperature. The 1938 and 1939 results seem to indicate that one heavy lead-oil-soap or lead-oil-Bordeaux spray applied in late July, is all that is necessary when a closely timed program of factory-mix nicotine-bentonite-oil is used during the first-brood hatch of codling-moth eggs. Both years' work show that harvest residues are not high, as a result of one lead-arsenate application, and that both lead and arsenic deposits can be easily removed by a short washing treatment at packing-shed temperature.

Spray Injury.—A first-brood lead-oil spray program was been followed on at least 50 acres of the Bedford orchard since 1933. When more than four cover

In 1939 there was almost no injury in either the large nicotine- or lead-sprayed areas. The exception was a few acres in the lead area on which the third cover was applied with a temperature of 94 degrees and a humidity of 75 per cent. Foliage on plot 2B (lead-oil-soap) gave no evidence of injury by the heavy lead spray on July 17, but plot 2C sprayed the same afternoon with 6 pounds of lead arsenate and one-half gallon of oil in $\frac{3}{4}$–$1\frac{1}{2}$–100 Bordeaux, quickly developed some marginal burn and a light leaf drop occurred four days after the spray was applied. In 1938 neither one nor two lead-oil-Bordeaux sprays, following first-brood coverage with nicotine-bentonite-oil, caused foliage injury or fruit russet.

Leafhopper Injury.—Leafhoppers were plentiful in the large lead-oil sprayed area in both 1938 and 1939. The nicotine-bentonite-oil greatly reduced the leaf hopper population, but some injury was evident especially on Winesap foliage even when eight applications were made as in 1938.

Fruit Size.—Residue samples taken before and after each spray and at harvest in 1938 seemed to indicate slightly larger fruit on the nicotine-sprayed area, but this difference was not apparent in 1939, possibly because the lead area did not receive a fourth cover around the bottom of the trees where all fruit samples were collected.

SUMMARY.—When more than four first-brood lead-arsenate cover sprays containing oil have been applied in the Bedford orchard, severe foliage injury, fruit russet and reduction in size of fruit has occurred, especially on varieties such as Jonathan and Grimes.

Good commercial control of codling moth has been obtained in recent years by a maximum of four first-brood-cover sprays, but it is believed that the success of such a spray program is quite dependent upon the size of the codling moth population, pruning to facilitate special coverage of the top third of the tree and also upon supplementary control measures, especially packing-shed sanitation.

A 15-acre test of factory-mix nicotine-bentonite-oil resulted in good codling-moth control, but required more frequent coverage than was the case with lead-arsenate-oil sprays.

An effort was made to work out a combination schedule using nicotine-bentonite-oil during the first-brood period of codling-moth attack and to follow this by one or two lead-arsenate-oil sprays to reduce spraying costs as well as take advantage of the high efficiency of lead arsenate during the latter part of the fruit-development period. Codling-moth control was satisfactory with this split schedule and foliage injury was negligible.

Lead and arsenic loads were determined before and after spray applications and at harvest and show the possibilities of producing a heavy and effective lead-arsenate film by one spray applied after the apples have reached a size of 7 to 10 fruits to the pound.

Washing tests conducted during two seasons show that a rapid washing treatment at packing-shed temperature, resulted in a high percentage residue removal which brought both arsenic and lead loads to tolerance on the fruit from the split-treatment plots.—2-24-40.

LITERATURE CITED

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Supplementary Spray Materials for Use with Nicotine Peat

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In response to recent demands for insoluble nicotine insecticides capable of standing up under outside weathering conditions, various attempts have been made to combine nicotine into some form that is more persistent than the sulfate or the free alkaloid, which have been in common use for some time. Nicotine peat (Markwood 1937) is an insecticide in which the solubility of nicotine in water has been reduced though not completely eliminated; at the usual spray strength about nine-tenths of the nicotine is insoluble.

In 1936 and 1937, when nicotine peat was first brought to the attention of entomologists, Steiner, Fahey, & Sazama† tested a number of supplementary materials, including soybean flour, mineral oil, rosin residue, and bentonite, for use in nicotine-peat sprays. Against codling moth larvae bentonite was found to be the most effective supplement to nicotine peat, but nicotine sulfate appeared to be just as effective with bentonite as did the new product, nicotine peat.

Because of the continued interest in the commercial possibilities of nicotine peat, and the fact that previous workers operating on a field scale had met with little success, it was thought desirable to undertake a more comprehensive study of the factors involved. The problem was accordingly brought back into the laboratory, and a search was begun for auxiliary spray materials that might prove suitable

* Resigned October 31, 1939.

† Unpublished data of the Bureau of Entomology and Plant Quarantine.

in sticking the nicotine peat more securely to the plant surface. The term "sticker" is used here to include any material added to the spray mixture to make the insecticide adhere in larger quantities or persist longer than it would otherwise. In this broad sense of the term it embraces both deposit builders and adhesives.

PREPARATION OF SPRAYS.—A series of sprays was prepared from a sample of nicotine peat containing 9.83 per cent of nicotine and the various supplementary materials. A spray of 0.048 per cent nicotine content was obtained by adding 14.5 grams of nicotine peat to water to make a total of 3 liters. For comparative purposes two nicotine sulfate sprays were prepared in like volume, to give a nicotine concentration of 0.050 per cent. The nicotine sulfate was made up as required from the pure alkaloid.

The water used in making up the sprays was artificially hardened as described elsewhere (Dawsey 1940). The pH value lay between 8.2 and 8.8, but when the sprays were made up, this was reduced to the acid side of the neutrality point to safeguard against the liberation of free nicotine.

The stickers and the methods of compounded them into spray form with nicotine-peat and nicotine sulfate were as follows:

1. Without sticker.—An aqueous suspension of nicotine peat without sticker or dispersing agent.
2. Petroleum oil.—The nicotine peat was added to an oil mixture contraining 13 cubic centimeters of a water-white, refined petroleum oil (95 seconds Saybolt viscosity at 100 degrees F.) plus 1.5 cubic centimeters of oleic acid. This oil suspension of nicotine peat was then emulsified in 200 cubic centimeters of water in a 500 cubic centimeter conical flask, by stirring with a high-speed drink mixer for 10 minutes. The concentrated emulsion so formed was then diluted to spray strength.
3. Petrolatum.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 grams of crude petrolatum plus 30 cubic centimeters of kerosene.
4. Paraffin.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 grams of paraffin plus 50 cubic centimeters of benzene.
5. Fish oil.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 cubic centimeters of crude menhaden fish oil.
6. Cottonseed oil.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 cubic centimeters of medium-grade cottonseed oil.
7. Varnish.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 cubic centimeters of a high-grade commercial varnish. The varnish itself consisted of 47 per cent nonvolatile material and 53 per cent of volatile. The nonvolatile portion contained 50 per cent of tung oil, 14 per cent of linseed oil, 34 per cent of phenol-formaldehyde resin, and 2 per cent of metallic driers. The volatile portion consisted of 25 per cent of turpentine and 75 per cent of mineral spirits.
8. Rosin residue.—Prepared as in spray No. 2, except that the oil mixture consisted of 14.5 cubic centimeters each of rosin residue (Goodhue and Fleming 1936) and kerosene.
9. Gum rosin.—Prepared as in spray No. 8, except that a gum rosin of medium grade was substituted for rosin residue.
10. Bentonite.—14.5 grams of Wyoming bentonite was wetted and suspended in 1.5 liters of water, and the pH value adjusted just to red side of methyl red indicator through the addition of dilute sulfuric acid. This bentonite suspension was then added to a nicotine-peat suspension in water and the total volume made up to 3 liters. A gray, flocculent, bulky precipitate resulted.
11. Without sticker.—An aqueous solution of nicotine sulfate having the pH value adjusted just to the red side of methyl red indicator.
12. Bentonite.—Prepared as in spray No. 10, except that the nicotine was added in the form of the sulfate. A white voluminous precipitate was formed when the bentonite suspension and the nicotine sulfate solution were mixed.

EXPERIMENTAL PROCEDURE.—The plants chosen for the experiments were rose bushes of the Madame Butterfly variety, three years old, about 18 inches high, and having about 1,000 normal-sized leaves each. They were grown in 10-inch pots because of the ease in handling during spray operations. Rose bushes had the advantage over other plants of comparatively persistent foliage and ease of buying or propagating.

The spray apparatus consisted of a 3-liter glass jar, a motor-driven churn agitator, a motor-driven rotary pump, and a hose with vermorel nozzle. A bypass was installed around the pump so that the nozzle pressure might be regulated by means of a feed-back valve. The pressure drop across the disk in the nozzle was kept at 50 pounds per square inch, as read on an attached gage, giving a delivery of fluid at the rate of 1.0 liter per minute. The stream leaving the nozzle was a solid cone of droplets rather than a mist.

The plants to be sprayed were placed upon a slowly revolving platform (20 revolutions per minute) with the axis of

rotation approximately 18 inches from the nozzle. The period of spraying was about twice the average run-off time. The spray stream was directed for 30 seconds onto the upper sides and for 30 seconds onto the undersides of the leaves of each plant. Two plants were sprayed with each mixture.

When the sprayed plants were dry, they were taken back into the greenhouse and disks 1.5 centimeters in diameter were clipped from the living foliage. A sample of 50 disks (25 from each plant), having a total area on both sides of 177 square centimeters was taken at once, and similar samples were taken at 7-day intervals thereafter for 4 weeks. Sprays 3 and 4 required 4 days to dry, and so the initial sample was taken at the end of this time. The samples were kept in small vials in a refrigerator until the end of the 4-week period, when all the disks were analyzed at the same time.

Nicotine determinations were made by distilling the nicotine from samples in the presence of alkali and then applying the photometric method recently developed by Markwood (1939). The distillate, amounting to 100 cubic centimeters, contained all the nicotine, and a 5-cubic centimeter aliquot portion was taken from this to make each test.

After the initial sampling the action of rain was simulated by washing all the plants 1 day before the subsequent samples were taken. The plants were placed, in turn, upon the revolving platform and sprayed with tap water from a shower-bath nozzle for 6 minutes. The rate of flow was approximately 6 gallons per minute. The nozzle was placed 18 inches from the axis of the plant and pointed upward at an angle of 45 degrees. The force and volume of water were such as to subject the residue on the foliage to a mechanical as well as to a solubilizing action. The mechanical action was undoubtedly more severe than that encountered in ordinary rainfall, though the solubilizing process, being of shorter duration, was somewhat less drastic.

The plants were exposed to direct sunlight in the greenhouse at Beltsville, Md., during August 1938. There were only 5 cloudy or partially cloudy days during the month, this period being one of the brightest of the year. The temperature in the greenhouse ranged between 60 and 80 degrees F., with a 90 per cent relative humidity, during the night, and between 90 and 105 degrees with relative humidity between 40 and 70 per cent, during the day.

A consideration of these facts indicates that the weathering, which includes the effects of rain, sunlight, high temperatures, and humidity, was generally more drastic than that encountered under outside conditions.

RESULTS.—Since coverage is an important factor governing the protection sprays give to plants, on the day following the application a record was made of the physical distribution of the residues adhering to the foliage (table 1).

Table 1.—Coverage obtained with nicotine sprays containing various stickers.

SPRAY NO.	STICKER	TYPE OF COVERAGE
	Nicotine-Peat Sprays	
1	None	Droplet, black spotty deposit
2	Petroleum oil	Droplet, but better than No. 1
3	Petrolatum	Droplet and film
4	Paraffin	Droplet and film
5	Fish oil	More film than droplet
6	Cottonseed oil	Film
7	Varnish	Film
8	Rosin residue	Most uniform film
9	Gum rosin	Medium uniform film
10	Bentonite	Heavy dirty blotches
	Nicotine Sulfate Sprays	
11	None	Droplet, residue nearly invisible
12	Bentonite	White blotches

Three general types of coverage were recognizable: The drying-droplet type, wherein the residue presented a spotty appearance due to the drying of large aqueous drops on the plant surface; the blotch type, wherein the residue consisted of large overlapping blotches; and the uniform or film type, where the residue was evenly distributed as if the solid particles had been deposited from a pepper shaker. The first of these was spotty, the second was capable of offering protection but its density varied greatly, while the third seemed most desirable because of uniform density and distribution.

The best sprays from the coverage standpoint were Nos. 8, 6, 7, 10, 9, 5, 2, and 12, given in order. Since Nos. 3 and 4 required 4 days to dry, they would be disadvantageous in field work, and sprays

Nos. 1 and 11 would also be disadvantageous in large-scale testing because of lack of uniformity in coverage.

In judging the potential usefulness of the sprays the two important factors to consider are the magnitude and the persistence of the toxic load. Table 2 gives the quantities of nicotine deposited on the foliage and the percentage of the initial deposit persisting from week to week and over the entire test period. Representative data are also pictured in fig. 1. The general performance of loads is expressed in the form of an assigned value, which has been termed the "time-load product," obtained by measuring, with a planimeter, the area under the respective curves illustrated in fig. 1. The time-load product is two-dimensional and may be thought of simply as the integrated product of insecticidal load and the length of time the load persisted. With the time-load products of sprays to which no sticker was added (Nos. 1 and 11) as base figures, relative ratings were calculated for each of the sprays containing stickers. Table 2 thus affords a concise summary concerning the size, persistence, performance, and rating of nicotine loads deposited by each spray.

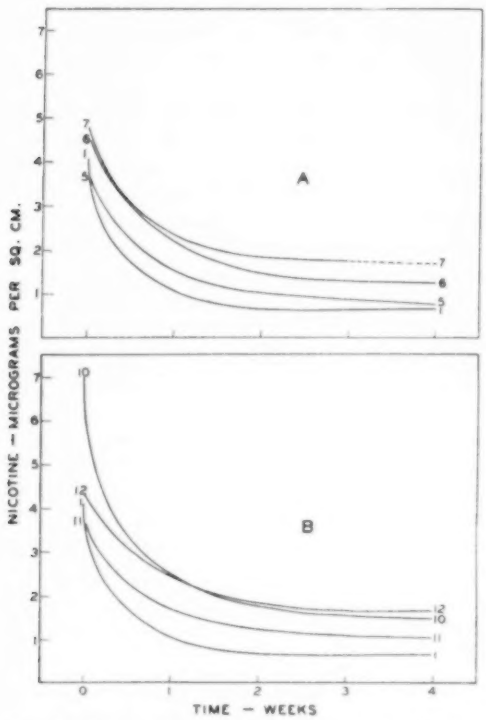

FIG. 1.—Persistence of nicotine on rose bushes when sprayed with different nicotine-sticker combinations. A, nicotine-peat sprays: B, nicotine sulfate and nicotine-peat sprays.

The addition of stickers to nicotine peat increased the persistence in every instance but one, gum rosin, and even in that case the initial load was improved. The most persistent stickers were varnish, cottonseed oil, and fish oil. From the standpoint of deposit building, as well as initial deposits, bentonite is important, and the three best sticking agents for nicotine peat become, in order, bentonite, varnish, and cottonseed oil.

In the nicotine sulfate sprays the addition of bentonite increased both the size and the persistence of the load. The use of bentonite with nicotine sulfate is not

Table 2.—Quantities and persistence of nicotine deposits and ratings of sprays containing different stickers.

Spray No.	Sticker	Micrograms of Nicotine per Square Centimeter After Spraying					Per Cent of Nicotine Remaining After Spraying					Time-Load Product*	Rating in Relation to Spray with no Sticker
		Immediately	1 week	2 weeks	3 weeks	4 weeks	1 week	2 weeks	3 weeks	4 weeks	Mean		
Nicotine Peat Sprays													
1	None	4.25	1.04	0.77	0.65	0.68	24	18	15	16	18	4.0	1.0
2	Petroleum oil	3.98	1.24	.77	.98	.98	31	19	25	25	25	5.0	1.3
3	Petrolatum	3.62	1.04	.68	.68	.47	29	19	19	13	20	3.9	1.0
4	Paraffin	4.78	2.43	1.66	.77	—	51	35	16	8†	28	7.2	1.8
5	Fish oil	3.77	1.54	1.10	.89	.77	41	29	24	20	29	5.2	1.3
6	Cottonseed oil	4.57	2.25	1.45	1.24	1.33	49	32	27	29	34	7.6	1.9
7	Varnish	4.89	2.37	1.90	1.75	—	48	39	36	35†	40	8.8	2.2
8	Rosin residue	5.37	2.43	1.19	—	—	45	22	10†	3†	20	6.6	1.7
9	Gum rosin	4.83	1.51	.95	.53	.47	31	20	11	10	18	5.1	1.3
10	Bentonite	7.08	2.37	2.02	1.63	1.30	33	29	23	18	26	8.9	2.2
Nicotine Sulfate Sprays‡													
11	None	4.00	1.88	.66	1.57	1.17	47	16	39	29	33	6.4	1.0
12	Bentonite	4.69	2.52	2.15	1.74	1.77	54	46	37	38	44	9.0	1.4

* Integrated product of load and time for period of 4 weeks.
† Estimated from the extrapolated curves.
‡ These deposits have been reduced by 4 per cent because the sprays were applied at 0.050 per cent concentration, whereas the nicotine-peat sprays were applied at a 0.048 per cent concentration.

new (Smith 1934, 1937). The spray was included here for the purpose of comparing some of the stickers applicable for use with nicotine peat, with bentonite, a supplement already established as effective for nicotine.

The stickers causing the greatest improvement in the nicotine-peat sprays as indicated by the relative spray rating (table 2), were somewhat better than bentonite in the nicotine sulfate spray.

Varnish, bentonite, cottonseed oil, paraffin, and rosin residue were all more effective stickers for nicotine peat than was bentonite for nicotine sulfate.

Some of the facts indicate that nicotine sulfate was superior to nicotine peat as a starting material in the preparation of sprays. For example, in a comparison between the no. 1 nicotine-peat spray and the no. 11 nicotine sulfate spray, both of which contained no sticker, the sulfate seemed superior although its initial deposit was below that of the peat spray. This is contrary to expectation, inasmuch as nicotine sulfate is known to be very soluble in water and under the conditions of these experiments might have been easily washed off the foliage during the first week. Again, in a comparison of the no. 10 nicotine peat and the no. 12 nicotine sulfate sprays, both containing bentonite, the sulfate seemed superior since it withstood weathering better in spite of a much lower initial deposit.

From all these considerations it is concluded that nicotine sulfate with bentonite added as a sticker was slightly better than nicotine peat with the same sticker.

PHYTOCIDAL EFFECTS.—The rose bushes were observed during the experimental period to record any apparent injury that might have been caused by the sprays. Two general types of injury were noticed, immediate and delayed. The immediate injury was characterized by fall of the older leaves, spot burning, and curling with burning at the edges of the younger leaves and shoots. The delayed injury was characterized by drying up of the center portions of leaves along the midrib and also by delayed leaf drop. The full effects of immediate injury were apparent within about 4 days after spraying, those of the delayed injury within about 2 weeks.

The only sprays appearing definitely to lack promise because of injury to the plants were those containing rosin residue, petrolatum, and paraffin. The rosin-residue spray caused very severe immediate injury, thought to be due to the terpene content of this material. The delayed injury caused by the petrolatum and paraffin sprays may have been due to the plastering over of the stomata of the leaves; moreover, the benzene added as blending agent in making up the paraffin spray may have been toxic to the plants.

Sprays giving a slight injury were those containing varnish, probably due to the turpentine content; the gum rosin, probably due to the kerosene used as a blending agent; and the cottonseed oil, probably due to the free fatty acids.

Fulton (1937), in a study of varnish as an adhesive for derris on cabbage and bean foliages, found no plant injury. He employed both slow-drying and fast-drying types of varnishes in concentrations ranging from 0.025 to 1.25 per cent by weight of the spray mixture, together with sodium lauryl sulfate as an emulsifying agent.

The varnish concentration in the work described herein was approximately 0.5 per cent, which falls within the range employed by Fulton, but since no emulsifying agent was added, more varnish may have been retained in these rose-bush experiments than in Fulton's work with cabbage and bean foliages. The varnish employed was the same as used by Fulton.

The only sprays giving no indication of growth impairment were those to which no stickers had been added or in which bentonite was the sticker. In the light of these facts bentonite seems to be the only outstanding sticker tested. It must be remembered, however, that the rose bushes employed in these experiments were more delicate than many other test plants that might have been selected, and the high temperatures, humidity, and sunlight to which the plants were subjected in the greenhouse might be considered by some to have been excessive.

CONCLUSION.—From the foregoing consideration of spray coverage, quantity and persistence of nicotine deposits, and plant injury, it must be concluded that bentonite was the most satisfactory sticker used with nicotine peat. A possible explanation of this is that the water-

soluble portion of the nicotine peat was fixed by the bentonite, resulting in the formation of nicotine bentonite. Other factors, not considered, which also favor the use of bentonite are the simplicity with which sprays may be prepared and, of course, its comparatively low price.

Varnish, while equally as effective as bentonite from the standpoint of time-load product, is more costly, and its use resulted in slight injury to rose foliage under greenhouse conditions. Cottonseed oil, fish oil, and petroleum oil appear more practical from this viewpoint than does varnish.

Summary.—A small-scale study was made of nine supplementary materials for use as stickers in conjunction with nicotine-peat sprays. These materials were petroleum oil, petrolatum, paraffin, menhaden fish oil, cottonseed oil, varnish, rosin residue, rosin gum, and bentonite. Tests were made on potted rose bushes in the greenhouse. Factors considered in evaluating sticker materials were physical distribution of the spray residue, quantity and persistence of nicotine deposits, and phytocidal effects.

Bentonite was the only satisfactory sticker of the materials tested. In a comparison between performance of bentonite as sticker for nicotine peat and for nicotine sulfate, the sulfate-bentonite proved to be slightly more effective than the peatbentonite combination.—3-20-40.

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Persistence of Nicotine on Rose Bushes Sprayed With Nicotine Sulfate Combinations

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At the time the work described in the foregoing paper was carried out, additional tests with nicotine sulfate were conducted for the purpose of obtaining a rating on certain nicotine spray combinations other than nicotine peat. Nicotine sulfate and molasses has been tried out for at least one season in the Pacific Northwest, nicotine bentonite has long been known to be effective, and recently Steiner & Sazama (1938) have found it possible to improve the formula in field practice through the addition of soybean oil. These three combinations as applied to rose bushes are considered in this paper.

The nicotine-bentonite spray was prepared as in no. 12 of the preceding paper. The methods of preparation of the other two sprays were as follows:

13. *Nicotine bentonite-soybean oil.*—To 1.5 grams of free nicotine in 1.5 liters of water, dilute sulfuric acid was added until just acid toward methyl red, and to this solution a suspension of 14.5 grams of bentonite with pH adjusted in a similar manner was added to produce the well-known flocculent, white nicotine-bentonite combination: to this was added 0.113 gram of sodium lauryl sulfate followed by 7.5 cubic centimeters of soybean oil, which was stirred in and emulsified with the electric drink mixer. Water was added to make a total of 3 liters.

In this formula the bentonite content was 0.5 per cent, whereas commercial formulas usually call for 0.6 per cent. The final mixture contained a voluminous, white mass, which occupied about three-fourths of the apparent fluid volume.

* Resigned October 31, 1939.

Table 1.—Quantities and persistence of nicotine deposits and ratings of nicotine sulfate spray combinations.

Spray No.	Sticker	Micrograms of Nicotine per Square Centimeter Spraying					Per Cent of Nicotine After Spraying					Time-Load Product*	Rating in Relation to Spray with No Sticker
		Immediately	1 week	2 weeks	3 weeks	4 weeks	1 week	2 weeks	3 weeks	4 weeks	Mean		
11	None	4.15	1.95	0.68	1.63	1.21	47	16	39	29	33	6.6	1.0
12	Bentonite	4.87	2.61	2.23	1.81	1.84	54	46	37	38	44	9.3	1.4
13	Bentonite and soybean oil	5.22	3.85	2.82	3.15	2.82	74	54	60	54	61	13.2	2.0
14	Molasses	3.47	1.28	.83	.86	.50	37	24	25	14	25	4.3	.7

* Integrated product of load and time for period of 4 weeks.

The nicotine content of all the sprays was 0.050 per cent. They caused no injury to the rose bushes.

14. *Nicotine sulfate-molasses combination.*—This spray was made from a proprietary nicotine-molasses product containing 2.15 per cent of nicotine: 70 grams of the material was dissolved in water and diluted to 3 liters.

The deposit obtained with the nicotine bentonite-soybean oil combination consisted of a film similar to that of gelatin on a photographic plate, and in uniformity and density was superior to any other spray tested. The molasses combination, on the other hand, gave a spotty deposit, which was no improvement over the poorest of other sprays tested.

Table 1 and figure 1 give the nicotine deposit and the percentage of the initial deposit found adhering to the rose foliage from week to week following application of these spray combinations and of a nicotine sulfate spray of the same nicotine content but with no sticker (No. 11 in previous paper). The time-load product and the rating in relation to spray with no sticker are also given in the table.

In any analysis of these data, regardless of whether the sprays are rated by only one or all four criteria of performances, the proper order of evaluation is as follows: Nicotine bentonite-soybean oil, nicotine bentonite, nicotine sulfate alone, and nicotine sulfate with molasses.

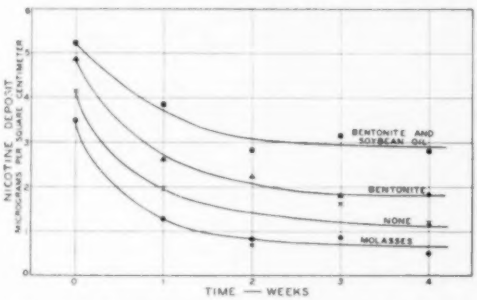

FIG. 1.—Persistence of nicotine on rose bushes when sprayed with different nicotine-sticker combinations.

It appears, therefore, that molasses was worse than no sticker at all, that bentonite offered definite advantages, and that the addition of soybean oil and bentonite together offered the greatest improvement in the compounding of a useful nicotine sulfate spray.—3-20-40.

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PEST CONTROL OPERATORS LICENSED IN ARKANSAS

The Arkansas State Plant Board has issued licenses to 64 applicants, 24 others having been rejected for failure to meet the requirements of the Board. Thirty-nine of the licenses were for the control of termites.

Operators reported treatment of 1,041 buildings during the year ending June 30, 1940. Inspectors found that 18 per cent of the buildings showed infestation within a year after treatment. Cost of the treatment to property owners was estimated at $125,000.

During the current year the Board expects to make monthly checks on the work of the operators.

Toxicity of Some Nitrogenous Bases to Eggs of *Lygaeus kalmii*

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The purpose of this investigation is to determine the toxicity of some nitrogenous bases to the eggs of *Lygaeus kalmii* (Stål.) under controlled laboratory conditions. In spite of the importance of controlling insects while they are still in the egg stage, a search of the entomological literature shows very few investigations of ovicides and most of these have been conducted under field conditions. It is only recently that laboratory tests bearing on the problem of ovicides have been conducted.

A great deal of work has been done upon nicotine as a contact insecticide, but comparatively little as an ovicide. Moore & Graham (1918) found that nicotine killed 100 per cent of the eggs of the Colorado potato beetle which were sprayed or dipped in the compound. McIndoo *et al.* (1921) tested the toxicity of nicotine sulphate upon the eggs of the silkworm moth, codling moth, tussock moth, and potato beetle. Using dilutions of 1–800, they found nicotine sulphate to be inefficient as an ovicide. Tattersfield & Gimingham (1927) found that 0.1 per cent nicotine gave a 100 per cent kill of the eggs of the geometrid moth, *Selenia tetraluneria* (Hufn). These workers also found that a 0.75 per cent sodium oleate solution (calculated as oleic acid) killed 100 per cent of the eggs of *Aphis rumicis*. Breakey & Miller (1935) found that one part nicotine sulphate in two hundred parts of spray killed 100 per cent of the eggs of the Angoumois grain moth; whereas basic nicotine was effective at the rate of one part in 750 parts of water. They also tested the toxicity of the two compounds to the eggs of the blow fly. Cochran (1936) tested basic nicotine in conjunction with sodium oleate and acetone on the eggs of "the large milkweed bug" *Oncopeltus fasciatus* (Dallas) under laboratory conditions. He found the median lethal concentration of nicotine in soap is about 0.062 per cent, and that for nicotine in acetone is about 0.07 per cent. Misaka (1938) has done a great deal of work testing the toxicity of nicotine sulphate to the eggs of *Chilo simplex* (Butler).

One of the first uses of quinoline as an ovicide was by Feytaud (1917) who employed it as a control for insect pests of the grape vine in France. Moore & Graham (1918) found that all of the eggs of the Colorado potato beetle were killed when they were dipped in the solution containing this compound. Cochran (1936) tested quinoline against the eggs of *Oncopeltus fasciatus* under laboratory conditions. He found the median lethal concentration of quinoline in soap and acetone to be about 0.06 per cent, and that for quinoline in acetone alone to be about 0.05 per cent. Shaw & Steer (1938) found quinoline to be non-toxic to *Aphis pomi* at 0.2 per cent, and to winter moth eggs, quinoline was not very toxic even at 0.5 per cent concentrations.

Moore & Graham (1918) tested pyridine on the eggs of the Colorado potato beetle, and found it to have very low toxicity. Shaw & Steer (1938) tested anabasine in the laboratory on the eggs of *Orgyia antiqua*, the vapourer moth, and on the eggs of *Aphis pomi*. They found it to have about the same toxicity as pyridine, and to be not nearly as effective as nicotine.

Many other compounds have been tried as ovicides, but this account deals only with the nitrogenous bases employed in this investigation. Lime-sulphur, oils, and various gases have been tested on insect eggs. Kagy (1936) tested the ovicidal properties of solutions of dinitro-o-cyclohexylphenol in petroleum oil on the eggs of *Lygaeus kalmii* (Stål.).

Biological Materials.—The eggs of *Lygaeus kalmii* are well suited for ovicidal experimentation. The eggs have a very high percentage of fertility, and they stand rather rough treatment without noticeable injury. They are also quite resistant to ovicides. Simanton & Andre (1936) developed a method of rearing *Lygaeus kalmii* in the laboratory so that the eggs can be obtained easily during the winter months in quite large numbers.

Chemicals.—The following compounds were used in this experiment: sodium oleate, U.S.P.; acetone, U.S.P.; synthetic quinoline with a boiling point between

110, and 111 degrees, Centigrade; pyridine, U.S.P.; nicotine containing 95 per cent free base; anabasine; and piperidine, the latter two having a high degree of purity.

METHOD.—The method employed in this investigation is similar to that described by Kagy (1936). Five groups of fifty eggs were used as samples making a total of 250 eggs treated with each concentration. Each solution received 0.25 per cent sodium oleate as a spreading and wetting agent, a concentration that had little, if any, toxicity to the eggs. Untreated eggs were used as controls throughout the experiment.

The eggs of *Lygaeus kalmii* undergo certain changes in color during their development. When first laid they are silvery white in color, and as development proceeds they change from a light yellow to a dark yellow. Just before hatching they become orange-red in color. These color changes make it possible to determine at what stage the embryos died from the various treatments.

RESULTS.—The data are plotted along a regression line according to the method of Bliss (1936). In using this method the logarithm of the concentration is plotted against the net per cent mortality expressed in terms of probits. Figures 1, 2, 3, 4, 5, and 6, show the mortality curves obtained for each of the compounds.

Table 1.—Comparison of median lethal concentrations and slopes.

COMPOUND	SLOPE	STANDARD ERROR	M.L.C.	STANDARD ERROR
			Per Cent	
Nicotine	2.22	0.21	0.11	0.05
Quinoline	3.5	0.36	0.12	0.04
Anabasine	4.29	0.05	0.18	0.01
Piperidine	2.57	0.22	0.29	0.03
Sodium Oleate	3.83	0.34	2.0	0.03
Pyridine	3.81	0.08	19.6	0.01

A comparison of the median lethal concentration is given in table 1, together with the standard errors of each. The slopes for each of the lines are also given with their standard errors.

DISCUSSION OF RESULTS.—The formula for the regression line of nicotine is $Y=5.75+2.22(X+0.69)$. By means of the chi-square test it was possible to determine how well the data agreed with the straight line relationship. A chi-square of 28.0, which was obtained, indicates that the data are either slightly heterogenous or that they depart a little from the straight line relationship. A close examination of figure 1, shows that possibly the latter is true, but that a straight line is probably a good average fit. The median lethal concentration (M.L.C. that which gives a 50 per cent kill) was determined from the computed line. For nicotine it is 0.11 per cent with a standard error of $\pm.05$.

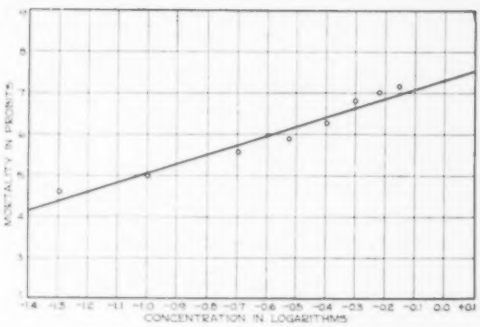

FIG. 1.—Toxicity of nicotine to eggs of *Lygaeus kalmii*.

The M.L.C. for quinoline is 0.1 with a standard error of $\pm.04$. The differences between the M.L.C. of nicotine and quinoline were tested for significance, and there was found to be no significant difference between them. Cochran[1] likewise found nicotine and quinoline to have similar toxicity to the eggs of *Oncopeltus fasciatus*.

Nicotine and quinoline had the highest toxicity to the eggs of *Lygaeus kalmii* of any of the compounds tested. In the case of quinoline, the equation for the regression line was $Y=5.35+3.5(X+.87)$. A chi-square of 20.1 was obtained which shows that again in the case of quinoline the data are either a little heterogenous or else deviate slightly from the straight line relationship. An examination of figure 2, shows that the points vary from the computed line in a similar manner to those of nicotine.

The M.L.C. for piperidine is 0.29 per cent with a standard error of $\pm.03$. The M.L.C. of piperidine differs significantly

[1] Unpublished thesis.

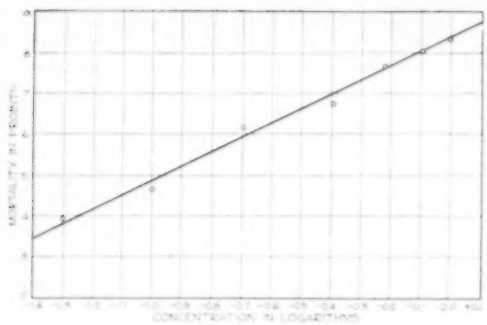

FIG. 2.—Toxicity of quinoline to eggs of *Lygaeus kalmii*.

from nicotine and a comparison of their M.L.C. shows piperidine to be about one-third as toxic as nicotine. The equation for the regression line of piperidine shown in figure 3, is $Y=5.29+2.57(X+0.35)$. Piperidine likewise had a fairly high chi-square of 26.9.

Anabasine has a M.L.C. of 0.18 per cent with a standard error of $\pm.01$. This M.L.C. was found to differ significantly from nicotine. This rather low toxicity of anabasine to insect eggs is of interest since other workers have found it to be considerably more toxic than nicotine to adult *Aphis rumicus*. Apparently anabasine is another compound of somewhat specific toxicity. The regression line for anabasine was found to have a decided break occur-

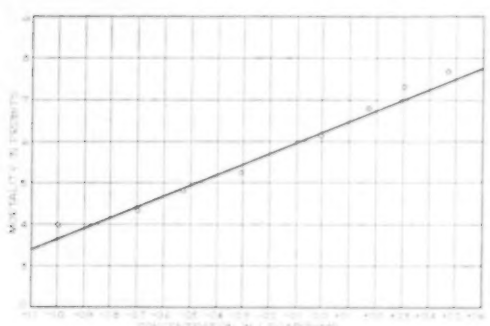

FIG. 3.—Toxicity of piperidine to eggs of *Lygaeus kalmii*.

ring at the probit value of 4. The lower points were omitted in the computation of the line, and an equation $Y=5.8+4.29(X+0.08)$ was obtained. In the case of this line, shown in figure 4, the chi-square of 1.6 shows that the data are quite homogeneous and are accurately represented by a straight line.

Pyridine has very little toxicity to the eggs of *Lygaeus kalmii*. Its M.L.C. was found to be 19.6 per cent with a standard error of $\pm.01$. Therefore nicotine is about 200 times as toxic to the eggs of *Lygaeus kalmii* as is pyridine. Other workers have

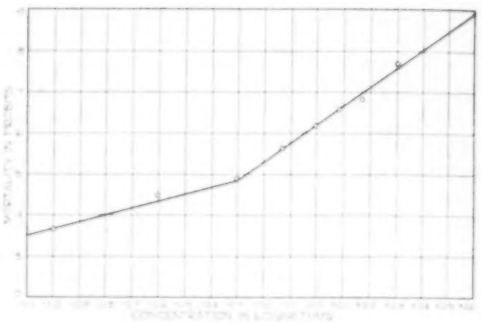

FIG. 4.—Toxicity of anabasine to eggs of *Lygaeus kalmii*.

likewise found pyridine to be much less toxic than nicotine. Again in the case of the regression line of pyridine, shown in figure 5, a break occurs at the probit value of 4. The lower points were omitted in the computation of the line, and an equation of $Y=5.11+3.81(X-1.32)$ was obtained. The chi-square of 5.8 shows that the data are quite homogeneous and are accurately represented by a straight line.

Sodium oleate was found to be toxic to the eggs of *Lygaeus kalmii*, and the M.L.C. was 2.0 per cent with a standard error of $\pm.03$. Cochran (1936) found sodium oleate to have very little toxicity to the eggs of *Oncopeltus fasciatus*. The equation for the regression line is $Y=5.23+3.83(X-.29)$, and a chi-square of 31.7 was obtained. These results show that the

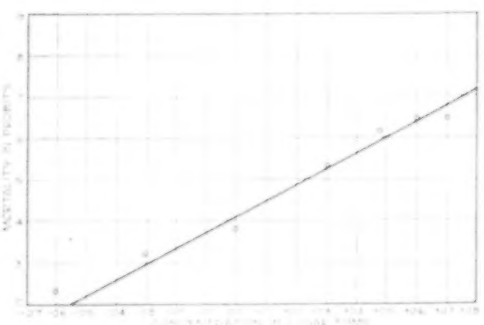

FIG. 5.—Toxicity of sodium oleate to eggs of *Lygaeus kalmii*.

data are somewhat heterogenous and that the line departs a little from the straight line relationship.

The following slopes were obtained for the various lines: nicotine 2.22, sodium oleate 3.83, quinoline 3.50, anabasine 4.29, piperidine 2.57, and pyridine 3.81. A comparison of their standard errors shows there is no significant difference between the slopes for nicotine and piperidine; however, the omission of some of the lower points in the case of the lines for anabasine and pyridine increased their apparent slopes so that these slopes are not comparable with the others.

A record of approximately when the eggs died in the various tests was kept and all the compounds, with the exception of quinoline, did not kill the eggs at once. Development of the embryos continued for several days, and in some cases they were able to hatch from the eggs but died soon after hatching. However, quinoline killed the eggs at once. Cochran (1936) also found this to be true when he tested quinoline on the eggs of *Oncopeltus fasciatus*.

Of the various compounds examined nicotine, quinoline, piperidine, and anabasine all show promise as ovicides.

SUMMARY.—Concentration-mortality curves for solutions of nicotine, quinoline, piperidine, anabasine, pyridine, and sodium oleate to the eggs of *Lygaeus kalmii* (Stål.) are presented.

The equations of the regression lines for each compound have been determined by the Bliss method, and the data have been analyzed statistically.

The descending order of toxicity based upon the median lethal concentrations in g. per cc. of solution is nicotine = quinoline, anabasine, piperidine, sodium oleate, pyridine.

The following median lethal concentrations (M.L.C.) were obtained: nicotine 0.11 per cent, quinoline 0.12 per cent, anabasine 0.18 per cent, piperidine 0.29 per cent, pyridine 19.6 per cent, and sodium oleate 2.0 per cent.

Nicotine, anabasine, piperidine, sodium oleate, and pyridine did not kill the eggs at once, and development of the embryos continued for several days. In some cases the young bugs were able to emerge from the eggs but died soon after hatching. Quinoline, however, killed the eggs at once.—3-29-40.

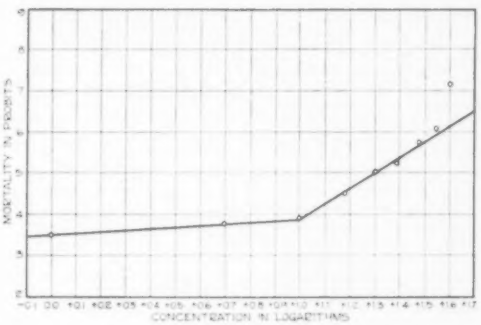

FIG. 6.—Toxicity of pyridine to eggs of *Lygaeus kalmii*.

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Insecticidal Action of Extracts of *Veratrum viride*[1]

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Veratrum viride Ait. has long been used as a drug and an insecticide. It is probably better known by its common names, green hellebore, American white hellebore, or American false-hellebore. The closely related European species, *V. album*, is known commonly as white hellebore. The *Veratrums* first came into general use in England during the 19th century as a control for gooseberry worms (*Nematus* sp.). In this country Fitch (1867) found white hellebore to be specific for the currant worm and suggested the use of the native *V. viride* as an insecticide. Both *Veratrum* species have been used since that time against a number of insect pests with varying degrees of success. Their use has declined in recent years, probably the result of insufficient knowledge of their active constituents. Although many investigators have demonstrated their insecticidal properties there have been conflicting reports of their value in insect control. Very few have attempted to determine the alkaloidal content of the drug used in their experiments, which has doubtless caused discrepancies in the results obtained.

Both chemical and biological methods have been used to evaluate *Veratrum* preparations for medicinal use. Among recent investigators Swanson & Hargreaves (1928) concluded that while there was some correlation between these two methods discrepancies often occurred. Similar findings have been reported by other workers in this field. No attempt has ever been made to correlate chemical assays with the insecticidal activity of the drug.

The purpose of this investigation was to determine the insecticidal action of the alkaloids extracted from the drug by various procedures. It is believed that this will be of value in the ultimate standardization of the drug should it be found to have practical value for insect control.

MATERIALS.—Although both *Veratrum viride* and *V. album* have been used in insect control this study was limited to the American species, *V. viride*. Two samples of the drug were employed, which will be designated as Sample A and Sample B. Sample A was purchased as the whole root, but, before testing, was ground to a powder which passed a 40 mesh screen. Sample B was purchased in the powdered form as "powdered American hellebore."

Analyses of the alkaloidal content of the drug were made by the method of Vichoever & Clevenger (1922), with some slight changes which are indicated below.

To a 10 gram sample of the powder, ground to 40 mesh, was added 150 cc. of chloroform-ether (equal parts by volume). After standing for 10 minutes, 10 cc. of distilled water and 1 gram of hydrated lime were added. The mixture was stirred constantly for an hour, then the liquid was filtered into a flask containing about 0.25 gram of calcined magnesia. The powder was then washed with several portions of chloroform-ether until the washings gave no precipitate with Mayer's reagent. The washings were added to the filtrate, and the mixture was shaken and filtered into a separatory funnel. This filtrate was extracted with three 20 cc. portions of 10 per cent acetic acid solution, and then with 10 cc. portions until the final extract gave no precipitate with Mayer's reagent. The acid extract was alkalized with ammonia, and in turn extracted with three 20 cc. portions of chloroform-ether, and as many portions as were necessary to extract the alkaloids completely. The extractions with the chloroform-ether solution were collected in a tared weighing bottle, evaporated before a current of air, and dried to constant weight at 80 degrees C.

Because assays by this method gave results that varied considerably, 1.30 to 1.71 per cent alkaloids on the same sample of powder, a change was made in the final extraction. The alkaline mixture was first extracted with ether until the ether extracts were negative to Mayer's reagent; then the extraction was continued with chloroform. Although the amounts of alkaloids extracted by the individual solvents varied somewhat, showing that the separation into two fractions was not

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exact, the total yields of alkaloids were generally quite consistent.

An aqueous extract of the drug was prepared for preliminary tests of its insecticidal action in the following manner. A 10 gram portion of the drug was placed in a flask with warm water and allowed to stand, with occasional shaking, for one hour. Then the mixture was filtered and sufficient sodium oleate added to make a solution containing 0.1 per cent of this material. The final solution, prepared in this manner, contained 0.28 per cent alkaloids soluble in ether. Further dilutions of this stock solution were made with 0.1 per cent sodium oleate. This aqueous solution was employed in tests with the aphids, *Aphis rumicis* L. and *Myzus persicae* (Sulz.), and the housefly, *Musca domestica* L..

A second aqueous extract was prepared by macerating 50 grams of the powder for 24 hours in 250 cc. of water. The aqueous solution was filtered off, and the powder was macerated in a second portion of 100 cc. for 24 hours. This procedure was followed until 1500 cc. of water were recovered. The last few 100 cc. portions were allowed to stand on the powder for 48 hours. Analysis of the combined aqueous filtrates with chloroform-ether indicated that 0.79 per cent alkaloids had been extracted from the drug. The residue resulting from this assay, or "water-soluble alkaloids," was tested for its toxicity to the American cochroach, *Periplaneta americana* (L.). Aqueous extracts of the drug have a rather high acidity, which probably accounts for the presence of the alkaloids in solution. When such a solution is made alkaline the alkaloids tend to precipitate out.

Residues resulting from the alkaloidal analyses of the whole drug were also employed for insecticidal tests. These included the fraction which was extracted by ether alone, "ether-soluble alkaloids," the fraction remaining after the ether extraction and subsequently extracted by chloroform, "ether-insoluble alkaloids," and the residue from the chloroform-ether extraction, "total alkaloids." These residues were tested on the American cockroach to determine their toxicity. A few additional tests were made with the German cockroach, *Blatella germanica* (L.) and the larger milkweed bug, *Oncopeltus fasciatus* (Dall.).

An attempt was made to prepare solutions of the alkaloidal residues for housefly sprays. However, it was very difficult to find a solvent for the residues which was miscible with the kerosene used in the spray. Ethyl alcohol seemed to render them miscible, but even then the alkaloids in the alcohol solution tended to separate out within a short time after being mixed with kerosene. Two solutions were prepared, containing 0.5 and 0.1 per cent alkaloids. The proportion of alcohol to kerosene was one part to nine parts by volume. A few tests were made with these solutions to determine their toxicity to houseflies.

METHODS.—*Aphids.*—The method of applying the aqueous extract to aphids, in a modified Tattersfield apparatus, was essentially that described by Craig & Richardson (1933). The extract was applied as a fine spray at a pressure of five pounds per square inch. With a delivery time of 20 seconds approximately 0.60 cc. of solution were applied. Samples of 10 insects were sprayed on coarse filter paper, and immediately transferred to nasturtium leaves, where they were observed for mortality. Control insects were sprayed with a 0.1 per cent solution of sodium oleate.

Houseflies.—A few preliminary tests were made with the aqueous extract on adult houseflies, the method being like that employed for the aphids. The larvae of the flies were reared on a food mixture similar to that described by Richardson (1932). The adults were fed milk for at least 48 hours before being used.

The flies were chilled, and kept in a tin container on ice to facilitate handling. Samples of 10 flies were employed in each test. After each sample was sprayed it was transferred to a small, screen cage in which was placed a vial containing a 15 per cent sucrose solution. The flies were then observed for mortality over a period of 48 hours. Controls were sprayed with a 0.1 per cent sodium oleate solution.

An attempt was made to spray flies with solutions of the "total alkaloids." Although the solutions prepared were not satisfactory, a few tests were made in a Peet-Grady chamber. Approximately 100 flies were sprayed in each test. Ten minutes after the spray was applied the flies were transferred to a screen cage in which milk was available as food. Examination

was made 48 hours after spraying to determine the per cent mortality.

Cockroaches.—The greater part of the experimental work was done with adults of the American cockroach, *Periplaneta americana*, the alkaloids being tested as stomach poisons. Three days before making a test, several cockroaches were placed in small, individual, screen cages. Strips of paper toweling, soaked in water, and placed under the tops of the cages, furnished a supply of water. Considerable mortality resulted if water was not supplied at least once daily.

No food was given the cockroaches during this three-day period. This starvation performed a two-fold purpose. During that time practically all the food material in the body was eliminated, making for more uniform tests, and weak individuals could be detected and discarded.

Baits were prepared by adding the residues from the assays to a mixture of ground rolled oats, sugar, and salt. Sufficient residue was added to make baits containing 10 per cent alkaloids.

The cockroaches were weighed on the last day of the starvation period. A weighed quantity of bait was then placed in each cage and left overnight. The following morning any uneaten bait was carefully removed and weighed to determine the exact amount consumed. If a cockroach ate no bait during the first night the bait was replaced in the cage until the next morning. Cockroaches which had not eaten after this length of time were discarded. By this procedure, the quantity of alkaloids eaten in milligrams per gram of body weight, was readily calculated. Cockroaches were weighed to milligrams, and the baits were weighed to 0.5 milligrams.

After feeding, the cockroaches were left in the cages with a supply of food and water for an observation period of one week. The insects that survived this period were considered unaffected by the alkaloids. The criterion of death was the failure of the insects to move when the legs or antennae were pinched with forceps.

Tests with a standard bait containing 20 per cent arsenic trioxide were conducted at the same time, and in the same manner as those with the alkaloidal residues.

A few tests were conducted with dusts prepared from the alkaloidal residues to learn if they had any contact effect on the German cockroach. Dusts containing 10 per cent, 2 per cent and 1 per cent of the alkaloids were prepared by mixing the alkaloids with talc.

Ten insects at a time were placed in a test tube and shaken to distribute the material thoroughly over their bodies.

Table 1.—Mortality of houseflies sprayed with an aqueous extract of *Veratrum viride*

Number of Flies	Per Cent Alkaloids Soluble in Ether	Net Mortality Per Cent
150	.023	87.0
100	.018	77.0
100	.011	74.0
100	.0096	48.0
50	.0056	43.0
50	.0048	32.0
50	.0028	28.0

The insects were then placed in a screen cage for observation. Tests with a pyrethrum dust containing 0.9 per cent pyrethrins were also conducted to compare roughly the effects of the two materials.

Larger milkweed bug.—A few tests were conducted with the larger milkweed bug, the materials and technique being the same as for the German cockroach.

Results.—*Aphids.*—Aqueous extracts of *Veratrum viride* had no toxic effect on the aphids, *Aphis rumicis* and *Myzus persicae*. The mortality of insects sprayed with these extracts was no greater than the mortality of control insects sprayed with 0.1 per cent sodium oleate.

Houseflies.—The results of tests with the adult housefly indicate definitely that preparations of *V. viride* have a toxic effect on this insect. Results obtained when flies were sprayed with the aqueous extract in a modified Tattersfield apparatus are given in table 1.

The net mortalities given in table 1 were obtained by correcting the observed mortalities for mortalities in the check populations. The average mortality in groups of check insects sprayed with 0.1 per cent sodium oleate was 6.0 per cent.

The few tests with the solutions of "total alkaloids" also indicated considerable toxicity of this material to houseflies, when sprayed in a Peet-Grady chamber. The average mortalities from solutions containing 0.5 per cent and 0.1 per cent

alkaloids were 77.0 and 33.0 per cent, respectively. The chi-square test showed that the results of individual tests varied much more than would be expected in random sampling. No doubt much of this variation resulted from the fact that the alkaloids would not remain in solution.

Cockroaches.—Crude alkaloids were extracted from both samples of the drug to determine if variations in toxicity might result from the source of the drug itself.

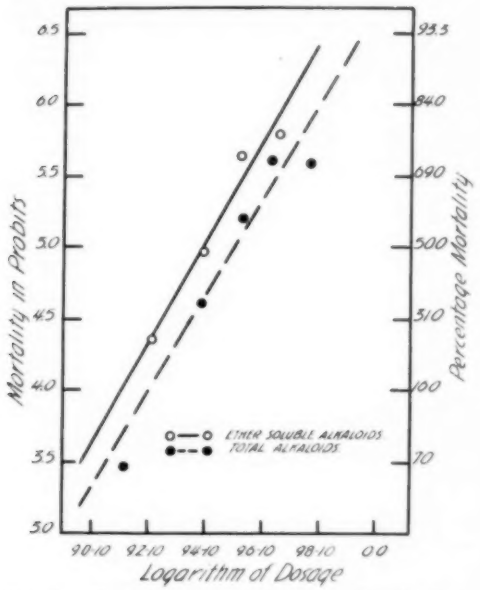

FIG. 1.—Toxicity of extracts from Sample A to *Periplaneta americana* adults.

Baits were prepared from these extracts and tested as stomach poisons against the American cockroach as described above. No mortality occurred in control insects which were given the same treatment as the experimental insects, but without the addition of alkaloids to their food.

The resulting data were analyzed by the methods given by Bliss (1935a, 1935b). Dosage-mortality curves for the various materials, based upon the mortality in probits and logarithms of the dosages, are shown in figures 1 to 3. Each point on the curves represents from 10 to 30 insects. Median lethal dosages, calculated from these curves, are given in table 2.

The "ether-insoluble alkaloids" had no effect upon the cockroaches at the largest dose given, which was 4.74 milligrams per gram of body weight. This material was much more repellent than any of the others, and the insects could not be induced to eat a larger quantity.

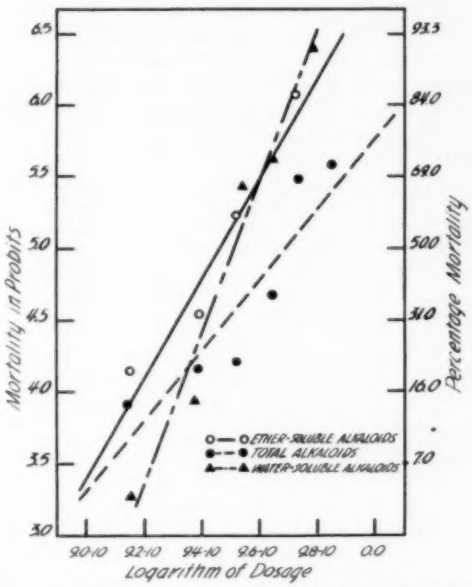

FIG. 2.—Toxicity of extracts from Sample B to *Periplaneta americana* adults.

The success of the technique was determined by applying the chi-square test to the mortalities resulting from the different dosages of each material. This test

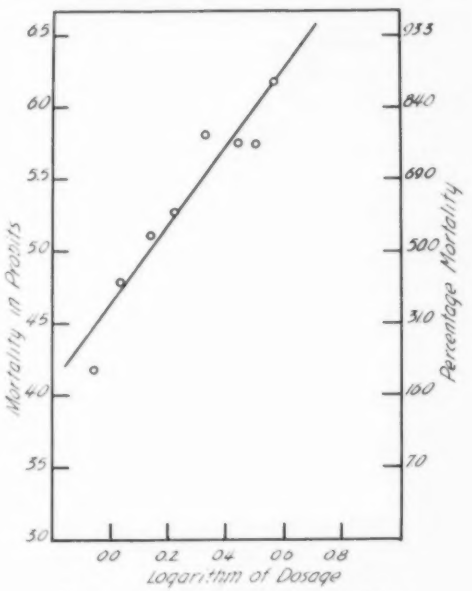

FIG. 3.—Toxicity of arsenic trioxide to *Periplaneta americana* adults.

showed that the mortalities varied no more than would be expected in random sampling.

The chi-square test was also used to compare the individual curves. This test showed that the "ether-soluble alkaloids" from the two samples of powder did not differ in their toxicity to the cockroach. The "ether-soluble alkaloids" and "total alkaloids" from the same sample of powder did show a significant difference in toxicity. This was to be expected, since the "ether-insoluble alkaloid" fraction was not toxic.

Table 2.—Median lethal doses, in milligrams per gram of body weight, of *V. viride* extracts and arsenic trioxide for *Periplaneta americana*.

MATERIAL	M. L. D. (mg./g.)
Sample A:	
1. "Ether-soluble alkaloids"	0.256
2. "Total alkaloids"	0.334
3. "Ether-insoluble alkaloids"	—
Sample B:	
4. "Ether-soluble alkaloids"	0.307
5. "Total alkaloids"	0.521
6. "Water-soluble alkaloids"	0.335
7. "Ether-insoluble alkaloids"	—
Arsenic trioxide	1.445

The "total alkaloids" from Sample A were significantly more toxic than the "total alkaloids" from Sample B. This difference may be explained by the fact that the "total alkaloids" from Sample A contained 74 per cent of the toxic, "ether-soluble alkaloid" fraction, while from Sample B they contained only 62 per cent.

There was no difference in the toxicity in the "water-soluble alkaloids" and "ether-soluble alkaloids" from Sample B.

There was no mortality from baits containing the whole, unextracted powder, although doses as large as 10 milligrams per gram of body weight were eaten. This quantity of whole powder would, however, contain only about 0.13 milligrams, of total alkaloids, a dose too small to produce much mortality.

Arsenic trioxide was much less toxic than any of the alkaloidal residues. The median lethal dose for arsenic trioxide was approximately five times larger than for the "ether-soluble alkaloids."

Symptoms of poisoning by the alkaloidal residues and arsenic trioxide also were very different. Cockroaches which had eaten lethal amounts of arsenic trioxide behaved in an apparently normal fashion for one to three days. Their movements then became increasingly sluggish until they finally died. Death followed in one to seven days after feeding.

Cockroaches poisoned by the alkaloids exhibited a state of extreme excitability within an hour after feeding. Then followed a definite paralysis of the appendages, and within four hours the insects, after falling on their backs, could no longer right themselves. After this time the only movement was a spasmodic twitching of the legs, which gradually grew weaker as death approached. The time from feeding until death ranged from 24 to 130 hours, with a mean time of 63 hours. No cockroach which exhibited any of the symptoms of poisoning recovered.

Table 3.—Mortality of *Blatella germanica* from dusts of *Veratrum* and pyrethrum.

MATERIAL	PER CENT MORTALITY
Whole *Veratrum* powder, 1.3% alkaloids	52.0
"Ether-insoluble alkaloids," 10%	0.0
"Ether-soluble alkaloids":	
10%	100.0
2%	52.0
1%	15.0
Pyrethrum powder, 0.9% pyrethrins	100.0
Controls	2.0

A few tests were made to compare roughly the toxicity of whole *Veratrum* powder, the alkaloidal residues, and pyrethrum powder, when applied as dusts to the German cockroach. Control insects were dusted with talc alone. The results of these tests are given in table 3.

These results indicate very well the relative toxicities of the different materials. The "ether-insoluble alkaloids" again had no toxic effect, while the "ether-soluble alkaloids" were quite effective, but were not as toxic as the pyrethrum powder.

Larger milkweed bug.—A few samples of *Oncopeltus fasciatus* were tested in the same manner as the German cockroach. Again the pyrethrum powder gave 100 per cent mortality. The mortalities from the 10 per cent and 1 per cent "ether-soluble alkaloids" were 100 per cent and 86 per cent, respectively. The "ether-

insoluble alkaloids" were non-toxic. Although the number of tests was limited, the alkaloids appeared to be more toxic to this insect than to the cockroach.

DISCUSSION.—These experiments have shown that certain extracts from *Veratrum viride* possess considerable toxicity to several species of insects, either as stomach or contact insecticides. Results of tests with the whole, powdered drug, however, were generally poor. This is readily explained by the fact that the toxic alkaloids are present in the drug in proportions too small to be effective. For general insect control it would appear necessary to extract the alkaloids, and employ them in a form more concentrated than they occur naturally in the whole drug.

With the perfection of practical methods of extraction it is possible that this drug can become economically important as a source of insecticide material. This is especially true since the plant is native to North America, and therefore readily available. There is also the possibility that other native *Veratrum* species might furnish a supply of the same alkaloids, since pharmacological studies, notably those of Hanzlik & De Eds (1927), indicate that the western species, *V. californicum*, contains the same active constituents as *V. viride*.

The alkaloidal residues were found to be very stable. Some of the preparations were kept in loosely covered weighing bottles for several months with no appreciable lowering of their toxicity to cockroaches. This fact would enhance considerably their value as insecticides should satisfactory methods for their extraction be devised.

The alkaloids in the drug may be separated roughly into two fractions: one soluble in ether, the other insoluble in ether but soluble in chloroform. The "ether-soluble alkaloids" possess considerable toxicity, being approximately five times more toxic to the American cockroach than arsenic trioxide. The "ether-insoluble alkaloids" were non-toxic to all the insects with which they were tested.

Water apparently extracts the same alkaloids from the drug as does ether, since the "water-soluble alkaloids" were as toxic to *Periplaneta americana* as were the "ether-soluble alkaloids" from the same sample of powder. Aqueous extracts had no effect upon the aphids, *Aphis rumicis* and *Myzus persicae*. This result agrees with the work of McIndoo & Sievers (1923), who reported that a spray prepared from *V. album* was ineffective against aphids.

There was no significant difference in the toxicity of the "ether-soluble alkaloids" from two samples of the drug to *Periplaneta americana*. "Total alkaloids" from the two samples did differ significantly, the total alkaloids which contained the greater percentage of the "ether-soluble alkaloid" fraction being more toxic. These experiments suggest that standardization of the drug for insecticidal purposes should be based upon the percentage of alkaloids soluble in ether, rather than the total alkaloid content. Further experimentation will be needed, however, before a satisfactory standardization by means of chemical analysis is possible.

SUMMARY.—*Veratrum viride* contains alkaloids which are very toxic to a number of insects. Perfection of practical methods of extraction may again make this drug economically important as a source of insecticide material.

Standardization of the drug should be based upon the fraction of alkaloids soluble in ether and not upon the total alkaloid content, since the fraction of alkaloids insoluble in ether is non-toxic.—3-29-40.

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Toxicities of Optically Active Nicotines and Nornicotines to *Aphis rumicis*

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In previous papers (Craig & Richardson 1933, and Richardson *et al.* 1936) the toxicities of *dl*-nicotine and *dl-nornicotine* against *Aphis rumicis* were examined. Racemic nicotine was less toxic than the *laevo* form, and the racemic nornicotine was of equal or slightly greater toxicity than *l*-nicotine. The question of the toxicities of the optically active isomers, particularly the *dextro* compounds, arose, and those compounds having become recently available, the purpose of the present work has been to continue the original experiments with these materials. All compounds in the present investigation have linkage through the beta carbon atom of the pyridyl ring.

MATERIALS.—Neutral sodium oleate U.S.P. was used in all sprays at the concentration of .25 per cent. Distilled water was used in making all dilutions. The toxic materials and their sources are described below:

l-Nicotine. Purified from the 95 per cent grade of commercial alkaloid by the method of Ratz (1905). Its specific optical rotation was −168.90 degrees.

d-Nicotine. This was prepared chemically by crystallization of *d*-nicotine *l*-tartrate from an inactive nicotine solution prepared by racemizing natural nicotine by heat in sealed tubes with sulfuric acid. Purification by repeated crystallization yielded a material of specific rotation of +166 degrees.

l-Nornicotine. Smith (1937) reported the presence of this alkaloid in *Nicotiana sylvestris* Spegaz and Comes. The material used in these experiments was obtained from leaves of *Nicotiana sylvestris* grown at Ithaca. The alkaloids were extracted from the dried leaves with gasoline and separation from the nicotine made according to Smith's method. It was found, however, that the plants used in this experiment yielded approximately 1.4 per cent crude alkaloids of which 57 per cent was nicotine and 43 per cent nornicotine. In Smith's work, his plants yielded about .95 per cent combined alkaloids of which 95 per cent was a nornicotine. The purified *l*-nornicotine had a specific optical rotation of −82 degrees.

d-Nornicotine. A sample of this material was kindly furnished by C. Stanton Hicks of the University of Adelaide who, with co-workers (1935, 1936), found the material to be present in the solanaceous plant *Duboisia hopwoodi* F. V. Muller. Its specific optical rotation was +84 degrees.

dl-Nornicotine. This was prepared according to the method of von Braun & Weissbach (1930) and purified by fractionation of the nitroso compound. Its rotation was not determined because of the small amount of the material but the melting point of the picrate (191–191.5 degrees C. against 191–192 degrees theoretical) indicates high purity.

METHODS.—With minor variations the same technique was used as described in previous experiments. Instead of spraying for 20 seconds, one cubic centimeter of solution was used. The deposit on the Petri dish was .42 to .49 gram which averaged 6.6 milligrams solution per square centimeter area. Possibly because this deposit is slightly lower than that in previous experiments (.56–.76 gram), the mortality of aphids in 18 lots of ten insects each sprayed with the soap check was only 2.2 per cent against 10 to 23.3 per cent in previous experiments.

Each concentration of each material was used against six lots of ten alate agamic females. Each figure in the accompanying table, therefore, is the average mortality among 60 aphids. The *d*-nicotine was used against six lots of 20

insects each at each concentration to preclude the possible necessity of repeating the tests because of variable data; this seemed advisable because of the small sample available.

The chi-square test for homogeneity was used on each group of six replicates. With the single exception footnoted in the table, the values of chi-square indicated the data to be within the range of normal variation (Fisher & Yates, 1938, probability values of .05–.95).

Table 1.—Mean per cent mortality of *Aphis rumicis*.

	Concentrations Used, Per Cent					
Material	0.005	0.02	0.05	0.2	0.4	2.0
l-nicotine	8	32	80	87	100	
d-nicotine			28	45	90	100
l-nornicotine	16	63	98	100		
d-nornicotine	16	45	65	100		
dl-nornicotine	13	37*	90	100		

* Chi-square shows range of replicates to depart significantly from a binomial distribution.

Tests were made over a period of two weeks in the greenhouse. No tests were made on sunny days because of the difficulty of holding the insects in the desired temperature range. The range of temperature over the test periods was from 70 to 85 degrees. F

RESULTS.—In table 1 and figure 1 are shown the gross mortalities in terms of per cent kill. It is apparent that *d*-nicotine is substantially less toxic than the other materials tested. All the nornicotines seem more toxic than natural nicotine, which substantiates earlier work with the racemic compound. *l*-Nornicotine is doubtfully more toxic than the *dextro* or inactive forms. A surprising feature of the data is the fact that although the *d*-nicotine is much less toxic than the *laevo* form, no such pronounced difference exists between the two forms of nornicotine. The data indicate that extracts of *Nicotiana sylvestris* and *Duboisia hopwoodi* may yield insecticides superior to nicotine in toxicity to some insects.

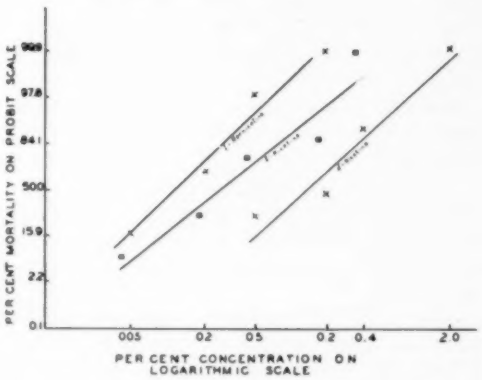

FIG. 1.—Toxicity of *l*-nicotine, *d*-nicotine and *l*-nornicotine to Aphis rumicis. Dosage-mortality lines for *dl*-nornicotine and *d*-nornicotine similar to that for *l*-nornicotine.

SUMMARY.—Toxicity studies in the laboratory of a group of optically active nicotines and nornicotines and of *dl*-nornicotine gave the following order of toxicities against *Aphis rumicis* L.: *l*-Nornicotine, *dl*- nornicotine and *d*-nornicotine were almost equally more toxic than *l*-nicotine. *d*-Nicotine was substantially less toxic than *l*-nicotine.—4-5-40.

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Peanut Oil in Derris Dust Mixtures Against the Pea Aphid

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It was shown by Fulton & Howard (1938) that the addition of crude peanut oil to derris sprays increased their effectiveness against certain plant bugs. These results suggested the substitution of crude peanut oil in place of various pine oils in conditioning derris dust mixtures. The pine oils already had shown considerable promise of increasing the effectiveness of such dust mixtures.

Results of experiments carried on during 1938 and 1939 in the greenhouse and in the field against the pea aphid (*Macrosiphum pisi* Kaltenbach) strongly indicate that the effectiveness of derris dust mixtures is increased appreciably by the addition of a small quantity of crude peanut oil.

The results further indicate that whereas this increase in effectiveness holds throughout all ranges of relative humidity obtained under greenhouse conditions it was especially prominent in the lower ranges. Under field conditions both temperature and relative humidity varied to such a degree from daytime to night that it was impossible to determine the influence of high or low relative humidity upon the comparative performance of any one dust mixture.

The derris dust mixtures compared during the course of these experiments were as follows: Derris-talc dust unconditioned; derris-talc dust conditioned with 1 per cent of sodium oleyl sulfate and 2 per cent of water; derris-talc dust conditioned with 1 per cent of sodium oleyl sulfate, 2 per cent of crude peanut oil, and 0.5 per cent of water, which previously had been emulsified together; and derris-talc dust conditioned with 2 per cent of crude peanut oil.

Greenhouse Experiments.—For use under greenhouse conditions all four derris dust mixtures were made up to contain 0.4 per cent of rotenone, this low percentage being necessary in order that aphid mortality would be reduced sufficiently that differences due to the presence or absence of conditioning agents could be recognized.

* Cooperating with the Wisconsin Agricultural Experiment Station.

During the first 3 months of 1938 the temperature at which the various tests were conducted ranged from 60 to 70 degrees but most of the time only from 64 to 68 degrees. This relatively low temperature was employed in order that comparatively low mortalities would be obtained. Thus it was possible to demonstrate the role which relative humidity played in the effectiveness of the different derris dust mixtures. The lower ranges of relative humidity were obtained in an open greenhouse, but to obtain the higher ranges it was necessary to employ temperature-humidity control chambers. The per cent mortality was recorded after 48 hours. The results of these tests are summarized in table 1.

Table 1.—Comparative effectiveness of derris dust mixtures at different relative humidities against the pea aphid under greenhouse conditions, 1938.

Relative Humidity, Per Cent	Derris* Mixture	Number of Aphids	Number of Tests	Average Mortality, Per Cent
20–39	1	875	4	1.6
	2	3,750	23	12.5
	3	1,375	9	76.0
40–59	1	1,768	13	7.1
	2	9,671	29	33.4
	3	1,056	14	75.4
60–79	1	465	2	56.0
	2	2,350	15	76.0
	3	845	5	96.4

* The derris powder contained 5.4 per cent of rotenone and 13.4 per cent of total extractives.

It is evident that under greenhouse conditions neither the unconditioned derris dust mixture nor the derris dust mixture conditioned with sodium oleyl sulfate alone was effective at the two lower ranges of relative humidity and only moderately effective at the highest range. On the other hand, the dust mixture conditioned with both sodium oleyl sulfate and crude peanut oil was moderately effective at the two lower ranges of relative humidity and highly effective at the highest range.

During the winter of 1938–39 an experi-

ment was conducted in which all four dust mixtures were tested under several ranges of temperature and of relative humidity. When all the tests with each dust mixture are grouped together the superiority of the mixtures containing peanut oil is evident. As with the tests recorded in table 1, these tests were conducted both in an open greenhouse and in temperature-humidity control chambers, and the per cent mortality was recorded after 48 hours. The results are summarized in table 2.

Under greenhouse conditions neither the unconditioned derris dust mixture nor the derris dust mixture conditioned with sodium oleyl sulfate alone was more than moderately effective under the ranges of temperature and relative humidity employed. On the other hand, the dust mixture conditioned with both sodium oleyl sulfate and crude peanut oil and that conditioned with crude peanut oil alone were highly effective.

Table 2.—Comparative effectiveness of derris dust mixtures against the pea aphid under greenhouse conditions at temperatures ranging from 58 to 72 degrees and relative humidities from 30 to 62 per cent, 1938–39.

Derris* Mixture	Number of Aphids	Number of Tests	Average Mortality, Per Cent
1	1,035	9	49.0
2	1,575	13	65.5
3	3,352	25	89.0
4	3,055	23	81.0

* The derris powder contained 5.1 per cent of rotenone and 15.6 per cent of total extractives.

FIELD EXPERIMENTS.—In field experiments against the pea aphid the derris dust mixtures were made up to contain 0.75 per cent of rotenone. They were applied to quarter-acre and half-acre plots of peas in replicates of four. A power duster mounted on a pick-up truck was used to apply the dusts. It was equipped with a 24-foot boom completely enclosed. In 1938 a 25-foot trailer was employed, which was lengthened to 40 feet in 1939. The reduction in the infestation was computed by comparing the average infestation in each treated plot with the average infestation in an appropriate check at various intervals for a period of 17 days.

For 8 days following treatment temperatures and relative humidities were as follows:

First 2 days.—Average temperature 66 degrees and average relative humidity 77 per cent.
Third and fourth days.—Average temperature 73 degrees and average relative humidity 71.5 per cent.
Last 4 days.—Average temperature 68.5 degrees and average relative humidity 84.5 per cent.

Table 3.—Comparative effectiveness of derris dust mixtures against the pea aphid under field conditions, 1938.

Derris* Mixture	Average Reduction in the Infestation on Indicated Day Following Treatment, Per Cent					
	2d	4th	8th	10th	17th	Average
1	63.0	78.0	90.3	90.7	33.5	71.1
2	59.5	72.5	89.0	89.5	38.0	69.7
3	72.0	85.5	91.9	95.2	61.5	81.2

* The derris powder contained 5.1 per cent of rotenone and 15.6 per cent of total extractives.

The results of these tests are summarized in table 3.

The average temperature was rather low for the first 2 days following treatment, although the average relative humidity was fairly high. Under these conditions there was little difference between the effect of the first and second dust mixtures. The third dust mixture, however, conditioned with both sodium oleyl sulfate and crude peanut oil was consistently superior to the other two throughout the 17-day period.

Table 4.—Comparative effectiveness of derris dust mixtures against the pea aphid under field conditions, 1939.

Derris* Mixture	Average Reduction in the Infestation on Indicated Day Following Treatment, Per Cent						
	2d	4th	6th	10th	12th	16th	Average
2	90.0	91.8	94.4	95.0	95.9	93.0	93.8
3	94.1	98.2	98.4	93.5	96.4	95.8	96.0

* The derris powder contained 3.9 per cent of rotenone and 17 per cent of total extractives.

On account of a very light aphid infestation in 1939, only the second and third mixtures were tested in the field.

For 6 days following treatment temperatures and relative humidities were as follows:

First 2 days.—Average temperature 72.5 degrees and average relative humidity 89 per cent.
Next 2 days.—Average temperature 72 degrees and average relative humidity 88 per cent.
Last 2 days.—Average temperature 66 degrees and average relative humidity 77.5 per cent.

The results of these tests are summarized in table 4.

In 1939 both the average temperature and average relative humidity were comparatively high for the first 4 days following treatment, consitituting very favorable conditions for a high mortality of aphids. Both dust mixtures resulted in excellent reduction in the infestation for a long period, mixture No. 3 giving greater reductions on 5 of the 6 days.

CONCLUSIONS.—It appears from the results of greenhouse and field experiments that the addition of a small quantity of crude peanut oil to a derris dust mixture appreciably increases its effectiveness against the pea aphid, and that the greater increases in effectiveness occur, in the greenhouse at least, when the relative humidity is comparatively low.—4-10-40.

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The Amazon Fly, *Metagonistylum minense*, A Parasite of the Sugarcane Borer

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Various foreign parasites of the sugarcane borer, *Diatraea saccharalis* (F.) have been introduced into Louisiana and to some extent into Florida by the Federal Bureau of Entomology and Plant Quarantine. The history of this work (Holloway 1939), dating from 1915, shows that many introductions have been made with few establishments resulting. Two species of foreign parasites promise to become effective in Florida, but in Louisiana the climatic conditions have on the whole not proved favorable to them and they have not become established as effective parasites.

The latest and apparently the most efficient parasite of the sugarcane borer yet introduced is the Amazon fly *Metagonistylum minense* Towns. This insect was discovered by Myers (1934) in floating grasses in the Amazon River in 1932. Dr. Myers made an adventurous trip up the river and across the Rio Branco savannahs to Venezuela. The object was to discover parasites of froghoppers, but other insects were not neglected. Great beds of floating grasses, both attached to the banks and floating as islands, were found infested with species of *Diatraea*, including *D. saccharalis*, the most injurious of the sugarcane borers. This species was found to be attacked by an unknown parasite which was afterwards given the common name "Amazon fly." The fly is a tachinid which varies in size but is characterized by having antennae enormously long for a fly of this family

This new parasite has been introduced into British Guiana and several islands of the West Indies where it has proved to be very efficient in the control of the sugarcane borer. A shipment of 50 mated females from Puerto Rico was sent to the Bureau laboratory at Houma, La., by K. A. Bartlett of the Puerto Rico Agricultural Experiment Station, in May 1938. In 1939, also in May, 40 mated females of the Saõ Paulo, or so-called dry-country strain of the same species was supplied by him.

These females were dissected according to the method devised by Scaramuzza (1932). The maggots in the ovary were removed and placed on larvae of the sugarcane borer.[1] Half-normal salt solution (29.22 grams of salt to 1,000 cubic centimeters of distilled water) was used to keep the maggots alive. A drop of solu-

[1] The best method of obtaining large numbers of the sugarcane borer is to rear them on corn according to methods found satisfactory for the European corn borer (1936).

tion was sufficient to wet an ovary full of maggots. The borer larvae were placed in a dish of the salt solution, and then removed one by one with the left hand and inoculated, under a binocular microscope, with from one to four or five maggots by means of a camel's-hair brush held in the right hand.

Dr. Bartlett recommended that each borer so treated be placed in a stalk of a food plant, and that these stalks then be placed upright in a metal or glass container having damp bagasse at the bottom and a wire-netting arrangement at the top and bottom to prevent the stalks from jamming together and molding. This method was used exclusively at first, and it was found to be satisfactory. Small sugarcane stalks were generally used, although cornstalks are also suitable. A cavity was cut in the stalk about an inch in length by a quarter of an inch in width and depth. The rind was not fully severed but was left to hang from the top. The inoculated borer was put into this cavity and then the piece of rind was replaced and held to the stalk with a rubber band. Boxes 10 by 10 by 14 inches were constructed of galvanized iron with screen on the ends. Damp bagasse was placed at the bottom, and then two grids or nets of wire were inserted, one near the bottom and one near the top, and held in place by ridged pieces of galvanized iron on two sides. The cane pieces were then set upright in these containers.

It may be seen that all this required much labor, but still more remained to be done. In about a week it was necessary to open the pieces of cane with a knife to allow the flies to emerge later. Otherwise as the pieces dried they would contract and tend to trap the flies. Also, while the borers were still alive they would work their way through the pieces and die in positions from which the flies could not extricate themselves. This condition does not occur in nature, as the growing plants do not contract and block the emergence of larval parasites.

To obviate all this labor another method of handling the treated larvae was devised. Into galvanized-iron pans, 24 by 13 by 2 inches, was placed a layer of damp bagasse, and the pans were then filled with shavings of sugarcane or cornstalks. (Pieces of corn ears in the blister stage were later found satisfactory.) Into these pans the inoculated borers were dropped. Over the pans were placed lids made largely of wire screen, and on top was spread a pad of wet cotton cloth. About 200 borers could be placed in one of these pans.

Experiments showed that, when used under carefully controlled conditions, the pan method was much more satisfactory, even aside from the great saving of labor, for many more flies issued from a given number of inoculated borers. However, the pan method requires special experience, whereas the box method is relatively fool-proof. If too much water is placed in the pan, a mass of rotting food material will result and parasite emergence will be low, while if the same thing is done to the box, the water merely runs off the pieces of food plant and the parasites remain in safety.

In a week or so the puparia of the parasite begin to appear. The pans and boxes are then placed in emergence cages 28 by 20 by 20 inches. At that time the lids are removed from the pans. After about another week the flies begin to emerge. The box method seems to delay emergence somewhat as compared with the pan method, but this delay is not enough to matter. The emerging flies are caught in glass tubes, and transferred to mating cages. These cages are made of white cheesecloth stretched on the inside of a cylindrical metal frame 10 by 14 inches, with pieces of white muslin at the top held in place by heavy rubber bands. Sections of old tire tubes are very good for this purpose. The cage dimensions given are of those used and found satisfactory, but other sizes may be quite as good.

A cage containing about 50 flies is placed out of doors in the shade. On warm days with a breeze, mating occurs readily. The flies are left out for one day. Pieces of absorbent cotton, some soaked in rain or distilled water, and others in a weak solution of sugar and water, are placed next to the cheesecloth on the outside, and held in place by the metal uprights of the cage. They should be changed every day or two, as the sugar solution must not be allowed to ferment.

The male flies can be distinguished from the females by the rather straight abdomen, ending squarely and abruptly, while the female abdomen curves from

the middle segments to a rather pointed end. This difference can be seen with the naked eye.

Having mated, the females produce maggots in about nine days. If the cages are left out in the laboratory the flies will move about, trying to escape from the cages, and soon die. This is prevented by placing the cages under a tent made of black cotton cloth, the ends of which hang in a tray of water. The details of this tent are as follows: A table 3 by 6 feet was equipped by a tinsmith with a tray 5 inches wide by 4 inches deep around all sides, like the gutter of a house. On this tray stands a metal frame 30 inches above the table, covered with the black cloth. The surface of the table itself is covered with black oilcloth, and on the oilcloth small pieces of wood are nailed to elevate the mating cages a little and thus provide ventilation from the bottom. The table is made ant-proof by setting the legs in jars or buckets of water having a film of engine oil on top.

The two strains of the Amazon fly, the original strain from the Amazon River and the Sao Paulo or dry-country strain, were found to require exactly the same treatment in the insectary. In both 1938 and 1939 there was a sharp decline in emergence toward the end of the summer. In 1939 a scavenger fly, probably *Chaetopsis debilis* (Loew), was thought to be partly responsible for this condition, as its larvae were found on the parasitized borer larvae, but the principal species causing trouble was doubtless a mite. The insectary room was fumigated with sulfur, 3 pounds to 1,000 cubic feet, and this was effective. Fumigation should be resorted to just as soon as a decrease in emergence is noted, if large numbers of mites are present.

The percentage of emergence is calculated in relation to the number of borers inoculated, not to the maggots used. In fast work it is hardly possible to state exactly how many maggots are handled. They are in constant motion, and some become concealed in the hairs of the camel's-hair brush, even though it is trimmed down.

The most unsatisfactory figure for emergence was zero in a pan when the mites were at their worst, and the most satisfactory figure was 165 per cent; that is, from 100 inoculated borers placed in a pan, 165 flies emerged. This pan was run with a box as a check, and the box gave 103 per cent. These figures, however, are considerably above the general averages, for in rapid work weak maggots and small borers were often used because better material was not available, whereas in the experiments an effort was made to use the very best material. Large borers, by the way, even those rather close to pupation, are the best, but pupae are not parasitized. The maggots should be lively and from ovaries with all the maggots developed, not from ovaries containing some unhatched eggs. Neither should maggots from dead flies be used. Of course, the use of undesirable material is sometimes necessary to keep the species alive, but it reduces the emergence.

Nine generations of the Amazon River strain were carried through in 1938, and six generations of the Saõ Paulo strain were completed in 1939 up to December 1. The emergence of the Amazon River strain ran from 23.8 to 118.5 per cent per generation, while that of the Sao Paulo strain ran from 11.5 to 76 per cent, being reduced by the prevalence of mites and scavenger flies. The smaller number of generations in 1939 was also due to these predators, as flies for dissection and inoculation were often not available. In 1938 a total of 3,612 flies were reared, and in 1939 the number was 3,217.

In the field 1,222 flies were released in 1938 and 1,904 in 1939. In 1938 the flies were kept for nine days before release, and many died. It is now believed necessary to keep them only three or four days.

Both strains of the Amazon fly were recovered soon after release; in fact, they were found to have destroyed a considerable number of borers. The Amazon River strain in 1938 killed from 8.4 to 52.2 per cent of the borers in the area surrounding the various spots of release, while in 1939 the Saõ Paulo strain was responsible for the death of from 3.3 to 58.6 per cent. At harvest time in 1938 Amazon flies were recovered in six of seven fields in which they had been released and in which examinations were made. In 1939 they were found in 11 out of 15 fields in which they were released earlier in the year.

In 1939 inspections were made of the fields where the Amazon River strain had been released in 1938. Amazon flies were

found in three of these fields, showing that they passed the winter successfully. One of these was on Grand Isle, an island south of New Orleans, where conditions are exceptional. The winter temperature is raised by the wide expanse of water, and the only cane field is a portion of an acre well protected by a windbreak of trees and bushes, and green sugarcane stands throughout the winter. One of the other two fields was about 1 mile and the other about 2 miles from points where releases were made in 1939, and it is possible that flies from the 1939 releases found their way to these fields.

The Amazon River and Saõ Paulo strains are distinguished by the former having brown areas on the abdomen whereas the latter has an entirely black abdomen. The abdomens of all flies recovered in the two release fields of 1938 which were near release fields of 1939 were black. It appears, however, that this differentiation of abdomen color may not be reliable in all cases. In these two fields shoots of summer-planted cane stood throughout the winter of 1938–39. Since borers are found all winter in such shoots, this planting practice may have provided easily found host material for the flies and thus may have enabled them to over-winter. Even in the fall of the same year of release the highest parasitization was usually found in summer-planted cane, and this planting practice may prove of much value in parasite establishment and maintenance.

The rearing work reported here was done at Houma, La., but flies were taken to Florida and released there during both 1938 and 1939. They were also reared by L. C. Scaramuzza at Fellsmere, Fla. This species is likely to be even more effective in Florida than in Louisiana, owing to the warmer climate.

In both its strains the Amazon fly is an efficient and adaptable parasite. It is easily reared and, unlike most introduced parasites, it can destroy many of the host insects within a few months. Should it fail to overwinter, it might be of value to rear and release it in good numbers for the control that it would give during the year of release. This parasite therefore appears promising as a factor in the eventual control of the sugarcane borer.

SUMMARY.—Among several species of dipterous parasites of *Diatraea saccharalis* (F.) introduced from the Amazon tropics into Louisiana and Florida is the tachinid *Metagonistylum minense* Towns. It is known popularly as the Amazon fly from having first been collected on floating grasses in the Amazon River.

The first consignment of 50 mated females came from K. A. Bartlett in Puerto Rico to Houma, La., in May 1938. A year later 40 mated females of a dryland form of the same species from Sao Paulo, Brazil, were received at Houma from Puerto Rico. Maggots were dissected from these flies and placed in half-normal salt solution. Larvae of *D. saccharalis* were placed in the same container and inoculated with four or five maggots each. The best method of rearing was found to be the placing of inoculated larvae in a covered galvanized iron pan 24 by 13 by 2 inches containing a layer of damp bagasse covered with shavings of sugarcane or pieces of corn ears in the blister stage. Such pans accommodated about 200 borers each. When, in about one week, the puparia appeared the covers were removed to allow the flies to emerge a few days later. The flies were mated in cheesecloth cages out of doors and given sugar-water as food. They produced maggots in about nine days after mating. The same technique was followed for both strains of this parasite. An invasion of parasitic mites in the laboratory was subdued by fumigation with sulfur at the rate of 3 pounds to 1,000 cubic feet of space.

From 100 inoculated borers the highest production obtained was 165 flies, but the average production was much lower. Large, fully fed borers were found best for most purposes. Nine generations of the Amazon strain were produced in 1938, and six generations of the Saõ Paulo strain in 1939, production in 1939 having been reduced by the invasion of mites. A total of 3,612 flies were reared in 1938 and 3,217 in 1939. Of these, 1,222 were released in 1938 and 1,904 in 1939. Flies of both strains were recovered soon after release and were found to have destroyed a considerable number of borers. Flies originating from the 1938 releases were taken from the same vicinity in 1939.

The Amazon River and Saõ Paulo strains of this fly are distinguishable by color differentiation.

This tachinid, in both its strains, appears to be an efficient and adaptable parasite of *Diatraea saccharalis*. in regions where the climate is suitable for its development. It is easily reared and is quickly fatal to its host.—2-22-40.

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The Locust Leaf Miner as a Pest of Soybean

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Because of the occasional occurrence of the locust leaf miner, now known as *Chalepus dorsalis* Thunb., as a pest of soybean, it seems desirable to record certain observations made during 1939, although no extensive investigations were conducted. This insect was reported by Fitch (1865) as severely injuring the foliage of black locust at Glen Cove, Long Island, N. Y. Since then many reports have been made of severe attacks in which the leaves of black locust turned brown and appeared from a distance as if scorched by fire. Such injury was observed by the writer to be extensive in northern Virginia and West Virginia and in western Pennsylvania during the summer of 1939.

An anonymous writer (1880) reported this species, under the name *Odontota scutellaris* Oliv., attacking various kinds of trees. Siberian crabapple and certain species of oak and elm were badly attacked whereas other species equally abundant and belonging to the same genera escaped. It was stated that "these tastes of the *scutellaris* are very singular." Hopkins (1896) reported adults of this leaf miner feeding upon white oak, beech, birch, hawthorn, and apple. He thought this indicated the possibility of a change in normal habits and that the insect might become destructive to the foliage of other trees, including the more valuable fruit trees. A number of host plants, some of which are not mentioned in this paper, have been recorded by the earlier writers. As these records are nearly all based only upon observations of feeding by the adult, the insect in some instances may have been confused with closely related species. Houser (1913) discussed this insect in an unusual role, namely, as a pest of apple in southern Ohio. More recently Dominick (1938) observed large numbers of a new brood of adults of this species feeding on oak. These later records and others not cited confirm the observations of earlier writers on the unusually wide range of food plants and emphasize the importance of the fact that one of the few plants in which the insect breeds is soybean.

That soybeans were severely injured by adults of the locust leaf miner in southern Ohio in 1912 was reported by Houser (1918), and similar observations were made in Green County, Pa., by Guyton (1926). DeLong (1925) reported, August 7, this insect attacking soybeans in southern Ohio as follows: "The feeding by this insect is much more severe than any feeding caused by the Mexican bean beetle upon the same crop. To the present time no egg masses have been found deposited upon soybeans and only the larvae which have migrated from other beans which were defoliated have been found upon soybeans. Feeding by the adult has been very meager in all cases."

Chittenden (1897) reported rearing this species from larvae found mining in leaves of soybeans grown on the grounds of the United States Department of Agriculture in Washington, D. C., and in discussing the plants apt to be attacked stated that it was not easy to account for the occurrence of this species on soybeans growing

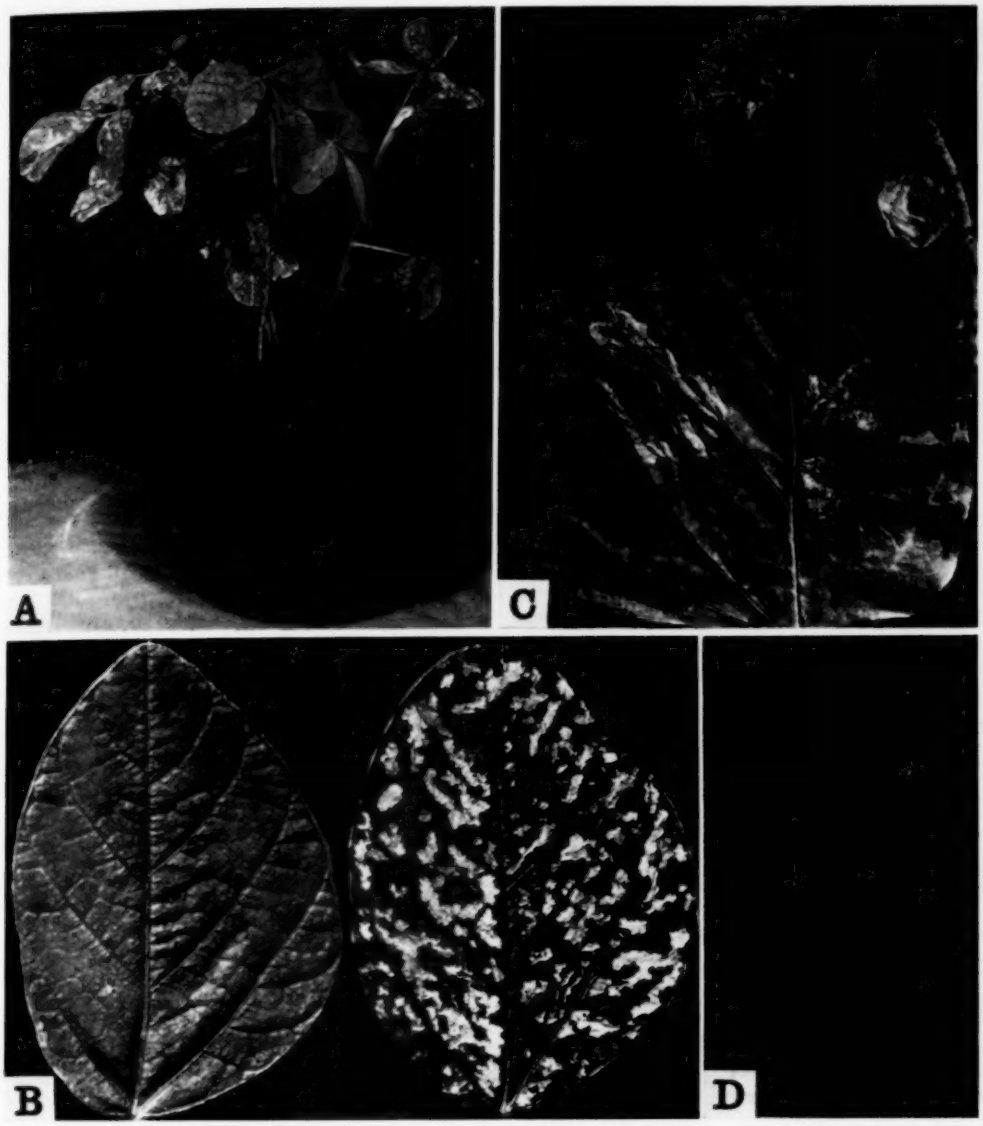

FIG. 1.—*Chalepus dorsalis* on soybean; *A*, Injury by adults in the field. Plants transplanted to 6-inch flowerpot for photograph. *B*, Feeding by adult on leaf, at right, compared with uninjured leaf, at left. *C*, Larval mines in leaf. Note pupa removed from one mine. *D*, Egg mass on lower surface of leaf. Eggs hatched and mine already started.

no nearer than 200 yards from black locust trees.

The writer first reared the locust leaf miner from soybeans in 1928. The plants were grown in the test plots of the Bureau of Plant Industry at the United States Department of Agriculture experiment farm at Arlington, Va. The insect was not particularly abundant there at that time.

In July 1939 attention was called to a severe attack on soybeans (Fig. 1, *A* and *B*) at Knoxville, Md., by adults that had recently emerged from the foliage of black locust trees. In response to a request for information on control measures, it was recommended that an application of derris dust containing 0.75 per cent of rotenone be made since these soybeans were intended for use as forage.

The grower made a heavy application of the dust, and an examination of the area 5 days later indicated that a very large percentage of the adult beetles had either been killed or driven away. The plants had made a remarkable recovery and were rapidly growing out of the injury. The adults showed no tendency later to deposit eggs on the plants, even on those not treated.

The observations at Knoxville led to a renewed interest in the soybeans grown at the Arlington Experiment Farm, where several hundred strains and varieties were being tested for various purposes. Several varieties were attacked by the leaf miner and some plants bore as many as 10 or 12 leaves containing mines made by the larvae. On August 1 and 8 a total of 108 infested soybean leaves were collected and the numbers of mines and individuals per mine were recorded. A maximum of four mines was observed in one leaf (Fig. 1, *C*) and a total of 144 mines were found, which contained 135 larvae, 23 pupae, and 4 adults. No more than 5 larvae, 2 pupae, or 1 adult were found in single mines.

A hymenopteron was reared from pupae taken from this material and was determined by A. B. Gaham as *Spilochalcis albifrons* Walsh. This species had not previously been recorded as a parasite of the locust leaf miner.

From brief observations on the biology of this insect it was found that the eggs are laid on the lower surface of the soybean leaves in much the same manner as described by Chittenden (1902) on black locust leaves. The egg mass (Fig. 1, *D*) contains from three to five eggs which are glued together and mostly covered by an excrementitious, glutinous substance. Chittenden thought this substance contained some caustic properties because an egg mass can always be seen on the upper side of the leaf as a small brown spot. The substance covering the eggs adheres to them so firmly that they cannot be removed from the mass without being destroyed. The position of the eggs in the mass is of interest because one end of each egg touches the leaf surface. The first egg of the mass is laid flat on its side and each succeeding one placed partly overlapping the previous one and therefore resting more obliquely.

Upon hatching the small larva breaks through the under side of the shell, enters the leaf below, and feeds on the tissue between the upper and lower epidermis, thus forming a mine. The boundary of the mine in which the larva completes its development and pupates is irregularly sinuate.

As stated above, the adults of the locust leaf miner observed at Knoxville showed no tendency to breed in the soybeans, but at Arlington breeding in soybeans was observed, several varieties being attacked. The nearest black locust trees were several hundred yards distant. It appeared probable that two broods developed in the plants during July and August, the last adults emerging the last week in August.

Because of the discriminating food habits of this species recorded in the earlier literature, and because of the differences observed in the habits of the individuals breeding in leaves of soybean and of black locust during 1939, it seemed possible that two different forms might be represented. Therefore, adults bred from the black locust at Knoxville, and adults, pupae, and larvae that had developed on the soybeans at Arlington, were submitted to the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for an opinion as to whether or not they were morphologically distinct. All specimens were identified as what is commonly referred to as *Chalepus dorsalis*.* Further observations are therefore necessary before it can be concluded that the forms feeding on soybean and on black locust are biologically distinct. —3-12-40.

* Grateful acknowledgement is made to H. S. Barber and W.H. Anderson for the study of this material.

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Poisons in Baits for Grasshopper Control

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The search for an economical and effective control of grasshoppers has been a problem for research workers for more than two centuries. Since the earliest report of damage by grasshoppers to cereal and forage crops in California in 1722, they have yearly taken their toll of cultivated crops, and in recent years records show that outbreaks have occurred on an average of once every 4 years, the grasshoppers persisting in outbreak numbers in many places from 4 to 8 years. In the earlier period of research the object was to find a poisoned bait that would kill, but later, owing to the enormous quantity of bait required, economy as well as efficiency has been an important consideration. The first use of an arsenical, paris green, was reported by Coe (1877) and the use of arsenic, sugar, and bran as a bait was reported by Coquillet (1886). Liquid sodium arsenite diluted with treacle was found effective in Natal (United States Department of Agriculture, Division of Entomology 1898) and paris green in a bait was reported by Simpson (1903) as having given satisfactory control. Many formulas have since been recommended for grasshopper control.

The purpose of this paper is to summarize the results of field tests conducted principally in California during the period 1924 to 1936 with liquid sodium arsenite, powdered sodium arsenite, paris green, and white arsenic, as toxic agents in grasshopper bait.

CONDITIONS OF THE EXPERIMENTS.—The locations in which the experiments were conducted ranged in elevation from 5,000 feet above sea level, in the Sierra Nevada, to 121 feet below sea level, in the Imperial Valley, and in type of vegetation from grassy meadowlands and alfalfa fields to desert land practically devoid of vegetation. The species involved were as varied as the conditions under which the experiments were conducted. Those of major importance were *Melanoplus mexicanus* (Sauss.), *M. marginatus* (Scudd.), *M. femur-rubrum* (Deg.), *M. differentialis* (Thos.), *M. devastator* (Scudd.), *Oedaleonotus enigma* (Scudd.), *Camnula pellucida* (Scudd.), *Sticthippus californicus* (Scudd.), *Aulocara elliotti* (Thos.), and *Dissosteira spurcata* (Scudd.). The stages of development ranged from first instar to adult, the greater number being in the later instars and the adult stage.

METHODS.—To determine the efficacy of different poisons used in bran bait, Student's *Z* test was used whereby the differences between the results of comparable experiments differing in the kind of poison and the amount of poison were tested for significance (Love 1924, Love & Brunson 1924). The baits were tested in different types of vegetation and were sown on comparable plots. The size of the plots ranged from ½ acre to 5 acres. All baits were sown within an hour to give the grasshoppers on the several plots equal chances to feed on the poisoned bait. A soil temperature of 66 to 70 degrees F. was used as an index for the time to begin sowing the bait and was usually the temperature at which the insects began to feed.

The baits used consisted of the poisons indicated in table 2 and in the text with the addition of 14 to 16 gallons of water

[1] The investigations reported here were conducted under the general directions of C. M. Packard, W. B. Cartwright, R. A. Blanchard, and L. G. Jones, to whom the writer is indebted for valuable suggestions and criticisms during the preparation of this paper.

to 100 pounds of bran. Liquid sodium arsenite and powdered sodium arsenite were each mixed with water and added to the bran, whereas paris green and commercial arsenic were mixed with the bran and the water was then added. The baits were mixed the evening before application was made and were sown at the rate of 5 to 10 pounds of dry bran to the acre.

Table 1.—Percentage of grasshopper mortality in field tests with baits containing 1 and 2 quarts of liquid sodium arsenite and 100 pounds of bran.

Size of Plot, Acres	Number of Samples	Mortality, Per Cent		Difference, Per Cent
		Two Quarts of Poison	One Quart of Poison	
2	1	66.0	69.0	3.0
2	1	57.8	77.0	19.2
½	1	58.1	56.7	− 1.4
½	1	55.1	60.4	5.3
½	1	55.6	55.8	0.2
½	1	53.9	51.6	− 2.3
½	1	66.9	60.4	− 6.5
½	1	44.9	24.4	−20.5
½	1	35.9	29.0	− 6.9
½	1	53.6	48.5	− 5.1
½	1	50.0	67.8	17.8
1	1	61.6	64.8	3.2
2	1	83.0	79.0	− 4.0
½	1	46.9	42.9	− 4.0
1	1	8.4	33.8	25.4
1	1	40.7	32.3	− 8.4
1	4	50.2	62.3	12.1
1	4	37.6	57.8	20.2
1	1	27.5	36.1	8.6
1	1	38.5	20.9	−17.6
1	4	35.5	54.8	19.3
5	20	77.1	76.9	− 0.2
1	1	96.4	84.2	−12.2
1	10	44.6	35.6	− 9.0
1	10	47.6	44.9	− 2.7
1	10	56.7	44.8	−11.9
1	5	65.8	64.5	− 1.3
1	5	26.7	27.6	0.9
1	5	38.1	39.3	1.2
1	10	15.2	15.7	0.5
1	5	32.2	30.3	− 1.9
1	5	34.0	35.6	1.6
32		1,562.1	1,584.7	22.6
Mean		48.82	49.52	0.70
Standard Deviation				10.76

Z = mean ÷ standard deviation = .065, odds 2.4: 1.

The method adopted for obtaining the percentage of kill was similar to that used by Ford & Larrimer (1921). From 3 to 24 hours after the bait had been sown grasshoppers sufficient to fill from 1 to 20 screen cages 6 by 6 by 10 inches in size were swept from each plot. The number of grasshoppers placed in each cage ranged from 75 to 200. Cages of unpoisoned grasshoppers were used as checks. All the caged grasshoppers were supplied suitable green food and were retained for 3 days after collection, the dead in each cage being removed daily and the number recorded. At the end of the experiment the grasshoppers that remained alive in the cages were sprayed with a pyrethrum-oil solution to stupefy them for counting.

The method of the statistical analysis of a representative set of data is illustrated in table 1. A summary of the comparative results obtained from each set of experiments, together with results of tests for significance, is given in table 2.

Liquid Sodium Arsenite.—In tests with liquid sodium arsenite ½ pint to 3 quarts of poison were used per 100 pounds of bran. Unless otherwise mentioned, the liquid sodium arsenite (30–32 per cent arsenic trioxide) was used in the tests reported in this paper. It was found that dosages of 1 pint to 2½ quarts were about equally effective when compared with a 1-quart dosage and that dosages of one-half pint and 3 quarts were less effective, as indicated by odds of 19 to 1 in the former case and 30 to 1 in the latter. It is highly probable that under field conditions a dosage of one-half pint was too weak and that a dosage of 3 quarts was repellent. The fact that 3 quarts of liquid sodium arsenite per 100 pounds of bran is repellent was demonstrated by experiments in which the baits were exposed on plates.[2] Swenk (1927), in Nebraska, also found 3 quarts to be less effective than 1½ quarts. In Natal (United States Department of Agriculture, Division of Entomology 1898) an effective control was realized when 2 ounces of arsenic in the form of liquid sodium arsenite was used in 5 gallons of treacle. Swenk obtained satisfactory control with 1 quart, and Corkins (1923a) recommended 1 pint of liquid sodium arsenite containing 50 per cent arsenic trioxide and indicated (1923b) that where a kill was desired in 24 to 48 hours 1 quart was desirable.

In the present experiments where 1 quart of liquid sodium arsenite containing 30 per cent arsenic trioxide was compared with 1 quart of liquid sodium arsenite containing 50 per cent arsenic tri-

[2] Unpublished notes.

oxide, per 100 pounds of bran, there were no significant differences between the two baits, as shown by odds of 1.83 to 1. As indicated above and in the data in table 2, it is evident that effective control may be obtained by the use of 1 pint to 2½ quarts of liquid sodium arsenite per 100 pounds of bran. In practical field tests conducted during the grasshopper-control campaigns from 1934 to 1938, however, 1 quart was found adequate. Where the poison is thoroughly mixed good results may be obtained by using less than 1 quart, but inasmuch as there is a chance that the poison may not be thoroughly mixed through the bait, it is recommended that 1 quart be used.

PARIS GREEN.—The use of paris green (50 per cent arsenic trioxide) in baits for grasshopper control is not new, and the results of the tests here given serve only to verify results obtained in other parts of the United States. Field tests were made to compare the efficacy of paris green when used in strengths ranging from 1 to 4 pounds to 100 pounds of bran. It was found that a dosage of 2 pounds proved slightly but not significantly more efficient than dosages of 1 and 4 pounds. In tests with various quantities of paris green versus 1 quart of liquid sodium arsenite, doses of 3 and 4 pounds of paris green were equal to the sodium arsenite in effectiveness, and a 2-pound dosage was significantly more effective than 1 quart of liquid sodium arsenite. The reason for this is not known, other than that many tests were conducted on moist ground where a portion of the poison may have leached out

Table 2.—Summary of differences in percentage mortality between various poisons in grasshopper baits.

POISON		NUMBER OF FIELD TESTS	MEAN DIFFERENCE, PER CENT[1]	Z	ODDS TO 1[2]
Liquid sodium arsenite, 1 quart, *versus:*					
Liquid sodium arsenite	½ pint	20	6.6	0.42	19.50
	1 pint	22	0.03	0.02	2.07
	1½ quarts	11	2.10	0.42	7.53
	2 quarts	32	0.70	0.65	2.40
	2½ quarts	13	1.70	0.15	2.24
	3 quarts	13	6.70	0.62	32.40
Paris green	1 pound	6	−3.82	0.25	2.32
	2 pounds	27	−6.53	0.37	20.10
	3 pounds	7	2.64	0.24	3.19
	4 pounds	10	−3.11	0.35	5.13
White arsenic	1 pound	10	−0.13	0.01	1.59
	2 pounds	9	0.64	0.06	1.55
	3 pounds	11	−1.05	0.11	1.64
	4 pounds	8	2.06	0.18	3.41
Powdered sodium arsenite	2 pounds	7	2.37	0.18	2.12
Paris green, 2 pounds, *versus:*					
Paris green	1 pound	10	6.78	0.39	6.67
	4 pounds	12	5.97	0.47	14.90
Paris green, 2 pounds, *versus:*					
White arsenic	3 pounds	5	5.48	0.77	9.82
	4 pounds	12	5.12	0.47	14.9
Paris green, 4 pounds, *versus:*					
White arsenic	4 pounds	16	−2.82	0.23	4.60
White arsenic, 2 pounds, *versus:*					
White arsenic	4 pounds	10	−2.68	0.26	4.11
Powdered sodium arsenite, 2 pounds, *versus:*					
Powdered sodium arsenite	4 pounds	8	−1.62	0.09	2.50

[1] Positive numbers in column 3 indicate odds in favor of first-mentioned poison in column 1.
[2] The differences in results from the paired tests are not considered significant unless the odds are at least 19 to 1.

from the flakes of bran in the liquid sodium arsenite bait. The 2-pound dosage of paris green was found sufficient by Ford & Larrimer (1921), and, although the use of this poison in grasshopper bait has been largely discontinued in the West because of its high cost, 2 pounds of paris green per 100 pounds of bran appears to be sufficient for practical field control of grasshoppers.

WHITE ARSENIC.—White arsenic was one of the first poisons to be used successfully in bran bait for grasshopper control. Its use was first reported by Coquillett (1886), and the formula consisted of 1 part of arsenic, 1 part of sugar, and 6 parts of bran, with sufficient water to make a moist mash. Since that time it has been used extensively in poisoned baits for grasshopper control. The cheapness and availability of white arsenic have contributed toward its continued use in poisoned bait, although in the Western States it has been replaced by liquid sodium arsenite. White arsenic is more dangerous to handle than liquid sodium arsenite, and exposure to the flying dust has often caused severe burning of the hands, face, and mucous membrane of the nose in members of the mixing crew. Also, the use of white arsenic requires more labor than the use of liquid sodium arsenite, because in order to obtain a thorough distribution of the poison it must be mixed first with the bran and then with the water.

The arsenic used in the tests reported in this paper contained 98.6 per cent of arsenic trioxide, and dosages of 1 to 4 pounds per 100 pounds of bran were used (Table 2). In these tests 1 quart of liquid sodium arsenite or 2 to 4 pounds of paris green compared with the amounts of arsenic used indicated no significant differences in effectiveness. Ford & Larrimer recommended 3 pounds per 100 pounds of bran and Swenk recommended 6 pounds. The thorough mixing of any poison with its carrier is a requisite for effectiveness, and although the 1-pound dosage was effective it is not recommended for practical field control of grasshoppers. From the present experiments it appears that either 2 or 3 pounds of arsenic per 100 pounds of bran can be used for field control with approximately equal results.

POWDERED SODIUM ARSENITE.—Powdered sodium arsenite has been used as a grasshopper poison for more than 25 years. It has been used more extensively as a dust and a spray than as a bait, especially in Russia and South Africa. Washburn (1912, p. 21) recommended the use of 1 pound of powdered sodium arsenite to 120 to 150 pounds of horse manure, and Veitch (1934) found that 2 pounds per 100 pounds of bran gave efficient control. In eight field experiments where powdered sodium arsenite (85 per cent arsenic trioxide) was tested at the rates of 2 and 4 pounds per 100 pounds of bran, and in seven field experiments where 2 pounds of powdered sodium arsenite was compared with 1 quart of liquid sodium arsenite per 100 pounds of bran, all mixtures were equal in effectiveness as indicated by odds of 2.50 to 1 and 2.12 to 1, respectively. Although efficient control may be had by the use of 2 pounds of powdered sodium arsenite to 100 pounds of bran, it should be used with caution because of its irritating effect on the mucous membranes of the nose and mouth.

SUMMARY.—An effective control for grasshoppers has been sought for more than two centuries. Records show that since the first published report (1722) on grasshoppers in California, these insects have taken an annual toll of cultivated crops. More recently, they have been sufficiently numerous to cause major outbreaks on an average of once in every 4 years.

The earlier workers were concerned principally in finding an effective poison. Later, when control measures were being applied on a much larger scale, economy as well as efficiency needed to be considered. During the period 1877 to 1903 paris green, white arsenic, and liquid sodium arsenite were reported as toxic agents used in grasshopper baits. Since that time many other bait formulas have been recommended.

During the period 1924 to 1936 liquid sodium arsenite, powdered sodium arsenite, paris green, and white arsenic were tested in varying quantities to determine their toxic effect in grasshopper baits. These experiments were conducted principally in California, in locations that ranged from 5,000 feet above sea level to 121 feet below sea level, embracing

grassy meadowlands, alfalfa fields, and practically barren desert. Ten economic species of grasshoppers were involved. The plots ranged in size from ½ acre to 5 acres. The relative efficiency of the poisons was determined by comparing the mortalities in the cages of grasshoppers collected from the poisoned plots. Student's *Z* test was used in determining the differences obtained in experiments wherein the kinds of poisons and the amounts used were varied.

Liquid sodium arsenite used at the rate of 1 pint to 5 pints, paris green at 1, 2, 3, and 4 pounds, white arsenic at 1, 2, 3, and 4 pounds, and powdered sodium arsenite at the rates of 2 and 4 pounds to 100 pounds of bran were equal in efficacy to 1 quart of liquid sodium arsenite, under conditions prevailing during these tests. Dosages of ½ pint and 3 quarts of liquid sodium arsenite proved less effective than 1 quart per 100 pounds of bran, the former being sublethal and the latter repellent.

The poisons and dosages per 100 pounds of bran recommended for control of grasshoppers in California are liquid sodium arsenite, 1 quart; paris green, 2 pounds; white arsenic, 2 to 3 pounds; or powdered sodium arsenite, 2 pounds.

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The Development of Research in Preventive Entomology

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In preventive entomology lies a most fruitful field for the development of research and for the operations of the professional consulting and practicing entomologists. It is believed that strategy has been greatly neglected in our tactics of combating the insect hordes that have destroyed man and his properties. Our energies have been expended more on combating the materialized attacks of insects than on preventing the formation of their destructive armies. In other words, we have tended to develop a system of economic salvage in emergencies due to insect attacks rather than strategic plans for preventing the development of destructive insect populations. From personal experiences, both in research and practical application, I feel that preventive procedure is most economical and usually most feasible. A logical procedure for research in preventive entomology has been studied by the writer for the last several years, and these remarks are presented with the thought of stimulating further studies along this

line rather than to suggest that a procedure in preventive entomology has been already established.

The basic findings and the application of any entomological study revolve about taxonomy and biology and, of necessity, these precede other investigations, but they will not be discussed except incidentally in setting forth the general plan which I have developed. The procedure for such a study is adaptable to any area and may be used for obtaining immediate results or for general long-time planning. It is believed that the greatest value of this plan lies in its application to extensive areas, that is, on the basis of a State or the entire affected area of the country and for a long time.

PROCEDURE OF STUDY.—*The general procedure* with any insect is first to obtain data on its numbers at various times and places, and then to set over against these data the factors that might affect the establishment and multiplication of the insect and see which of these have consistently operated in the same way. From these affecting factors some may be found that are easily controlled by man and may be used to effect the extermination of the insect or at least to bring it under some measure of control. Naturally the operative factors most desirable will be those that can be controlled with the least expense and without restricting the acreage of valuable crops or the raising of the desired kinds of farm or range animals.

Obtaining a census of the insect's population is the first step. The technique of taking the census and determining the status of the insect's population will vary according to the habits and life cycle of each group of insects studied. Developing this technique presents a most fruitful field for research. The most common method is by taking trapping or area-counting samples of one or more life stages of the insect. Most of the data thus far obtained on the status of insect populations have been local, fragmentary, and intermittent. The most valuable data for coordination with affecting factors and for determining preventive measures will be those compiled from data covering the entire distributional range of the insect, accurately determined numbers, and continuous record of the insect's population, over long periods of time.

DISCUSSION OF FACTORS.—*Factors affecting insect populations* are conveniently segregated into the five major divisions as follows: Climate-weather, host, dissemination, biological, and other geophysical or miscellaneous factors. Each of these divisions is made up of innumerable secondary and minor influencing factors, and many of these must be studied individually. The climate-weather division breaks down into temperature, rainfall, wind, sunshine, etc. These in turn break down into rate, intensity, continuity, etc. Other major groups break down in much the same way. The biology of many, if not most, insects is highly specialized. The climatic, host, disseminative, biological, and miscellaneous conditions under which an insect can establish and build up populations are usually rather narrow for at least one or more of the affecting factors or subfactors. The value of these suggested studies lies in taking advantage of the narrow limits within which the insect can establish itself and thrive. The value of any factor in this type of research is determined by the cost of obtaining the data and by its usefulness when preventive and control measures for the insect are being formulated. The value of any factor in preventing or controlling the insect's population is determined by the degree of control of the insect which it makes possible, and the cost of controlling the factor.

The climate-weather factor has been the basis of these studies. Climate is a limiting factor in the distribution and numbers of all forms of life; it determines absolutely the parts of the world in which any species can establish and develop a population. Weather is a controlling factor in establishing, building up, and eradicating insect populations; this is especially indicated in the fringe of distribution of many insects where climate is the principal limiting factor. Temperature, rainfall, wind, etc., also are each absolute in determining the establishment, building up, and eradication of many insect populations. In our early work climate and weather data were used as determined at the site of the studies. More recently data as collected by the Weather Bureau have been used in extensive area studies and have been found adequate. These data are available for most of the world, and are a valuable asset in any studies on insect prevention.

The climate-weather factor is useful in research on insect populations in evaluating other factors. In practical application under natural conditions this factor cannot be controlled, but the effects of it may be controlled to some extent, and the time and place for the control of other factors may be indicated.

The host factor usually can be controlled by man. Since many insects have a very narrow range of host materials, this factor may be used most effectively in the control of such insects by host elimination for certain periods, development of host resistance, and the continued development of more practical insecticides and repellents. The host factor is partially or completely controlled by the climate-weather factor, and in turn the host factor completely controls the insect populations.

The dissemination factor controls the establishment or reestablishment of insect populations. There are three agencies of dissemination, migration, transportation by natural agencies, such as wind and water, and transportation by animals and man. There are also three methods of combating dissemination, controlling or eliminating the insect at its source, preventing or retarding its movement, and resisting or preventing establishment. Prevention of movement of insects by quarantine has been, and is, a most effective deterrent to insect dissemination. Travel and transportation by man have increased to such an extent that quarantines are becoming more expensive and less effective. It is believed, however, that there is a fertile field of research in the development of methods to control insects at their source, to prevent or

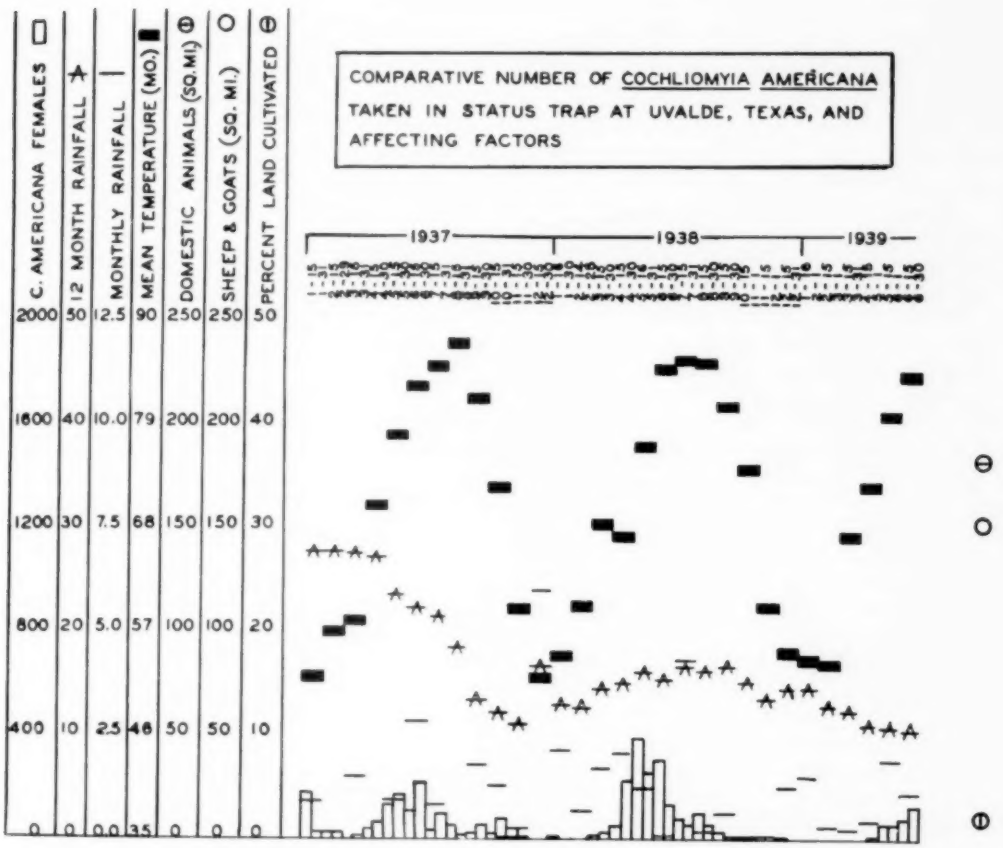
COMPARATIVE NUMBER OF COCHLIOMYIA AMERICANA TAKEN IN STATUS TRAP AT UVALDE, TEXAS, AND AFFECTING FACTORS
1937
1938
1939
C. AMERICANA FEMALES
12 MONTH RAINFALL
MONTHLY RAINFALL
MEAN TEMPERATURE (MO.)
DOMESTIC ANIMALS (SQ. MI.)
SHEEP & GOATS (SQ. MI.)
PERCENT LAND CULTIVATED
2000 50 12.5 90 250 250 50
1600 40 10.0 79 200 200 40
1200 30 7.5 68 150 150 30
800 20 5.0 57 100 100 20
400 10 2.5 46 50 50 10
0 0 0.0 35 0 0 0

FIG. 1.—Population of screwworm flies at various dates.

mitigate the establishment of insect populations, and to provide a more feasible application of quarantine. Climate-weather and host factors have an important influence upon insect populations, and may become absolute as regards the source of these populations and their establishment. They may restrict or completely control insect movements.

The biological factor is practically always restrictive on insect populations but rarely, if ever, becomes absolute. This factor has been advantageously employed in insect control and still has its place in research. The climate-weather factor is absolute in the limitation of biological control and nearly, if not always, mitigates its operation.

Miscellaneous factors, as grouped, are mostly geophysical—topography and cover or use of terrain, animal and plant associations, etc. They are a class of factors that are more or less stable for time periods and affect other factors rather than being affected by them. Control or changes of geophysical factors effected by man or natural agencies are usually gradual. Their value in studies of applied entomology, both preventive and remedial, lies in the planning of terrain and commodity use.

DISCUSSION OF DATA AND CORRELATIONS.—*The data on which the plan of study is based* are too voluminous to be presented in these remarks. Most of the data are on insects affecting man and animals—the sticktight flea, *Echidnophaga gallinacea*, the fowl tick, *Argas miniatus*, *Hippelates* spp., and blowflies. The greater part relate to blowflies and their parasites and predators, and on these alone several million units of comparison have been accumulated. The cost of obtaining these data has been very nominal as compared with other work and with its demonstrated value in control and eradication of these pests and the economic use of their insect enemies. The expense has been materially reduced by the use of basic climatic and weather data made available by the Weather Bureau, and by cooperative work with other federal, State, and local organizations, and individuals.

Coordinating the data has been rather difficult for the reason that there have been innumerable affecting factors operating simultaneously on insect populations. Several procedures of statistical analysis have been used. A correlation chart has been developed and has proved useful at least in preliminary correlations. Chart No. 1 (time) (Fig. 1) gives a fair picture of the screwworm fly population and coordinated factors for a time period at a place. Chart No. 2 (place) (Fig. 2) gives this picture for a concurrent period at several places. The data used have been accumulated by periodic sampling with traps in several hundred ecological areas. Temperature and rainfall records are not available in all of the localities for which fly trapping and other data are presented.

The charts have horizontal base and top lines and vertical columns. Horizontal guide lines divide these vertical columns into 100 equal units. The fly population limits for all determined places and time periods are known and the lowest figure is placed on the base line and the highest on the top line in one of a row of columns at the left of the chart. Each guide line in that column (or every five or ten lines) is marked with a figure representing its proportionate step in the total possible fly population. In Chart No. 1 the highest population provided for is 2,000 per trap, and as the base line is zero in this case each of the 100 steps marked off by the guide lines represents a catch of 20 flies per trap. All factors to be studied are treated in the same way. In constructing the body of the chart the population status is represented by a solid color of the column from the base to the guide line representing the number of flies caught for the period. The relative value of each factor is then determined for the period and represented by placing a symbol on the determined guide line, in the trap-period column if it varies for each period for time or place, or in a column at right of chart body if it is constant for time or place.

The interpretation of the data is complicated, but some examples may be enlightening. If on the charts we have a mean temperature range of from 40 degrees (base) to 90 degrees (top) but the fly catch is 0 for all periods for both time and place except between 55 and 80 degrees, we know that, for the data at hand, the absolutes for temperatures have been determined for adult activity. If all peak catches are between 65 and 75 degrees,

this is indicated as the optimum or most favorable temperature. We will note that the highest peaks occur in brushy areas with high domestic animal populations per unit area with the following two exceptions: One with a high deer but low domestic animal population and at fawning time, and the other with a low unit area population of goats and sheep that populations is either noneffective or the data studied do not include an effective range. If the mean temperature range for the studies had been between 65 degrees and 75 degrees such a factor would have been negative.

These examples indicate only the adult activity. To complete the study all stages of the fly must be included.

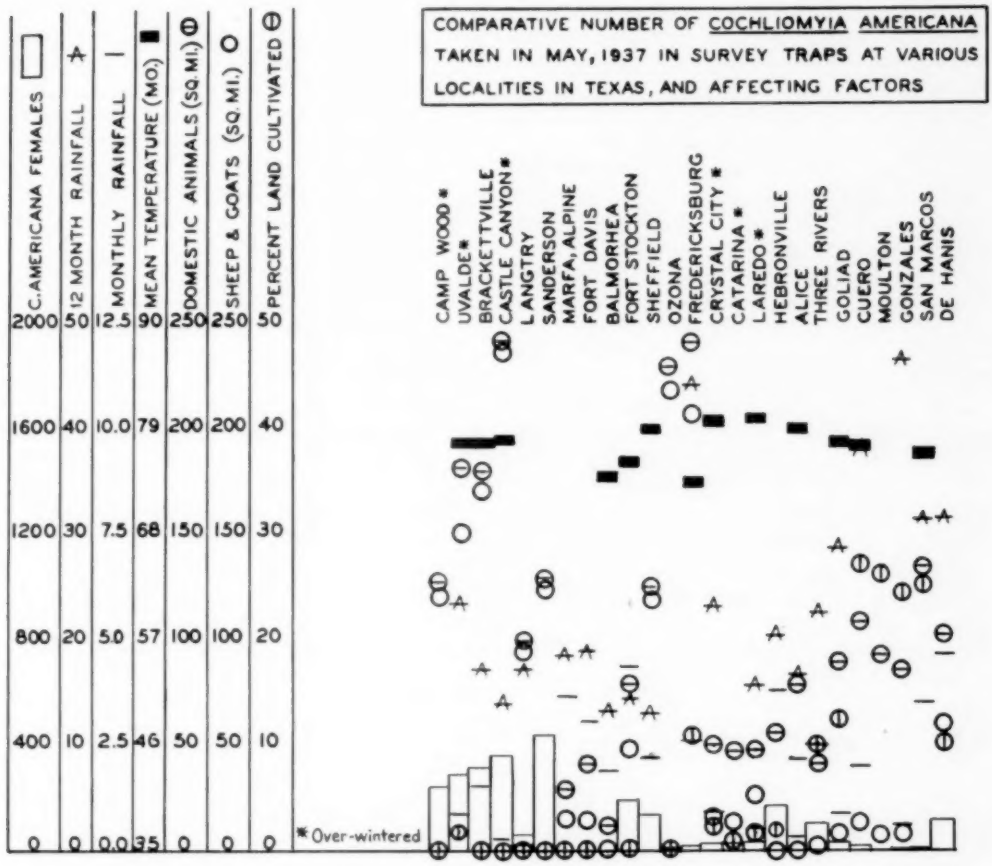

FIG. 2.—Distribution of screwworm flies during May.

have recently been sheared by a crew of careless shearers. In these instances the host material factor is indicated, as is the geophysical factor—brush cover. We may also note, both for time and place, that in any area with small holdings where all animals are domestic and are inspected daily the fly population is nil or low regardless of unit-area animal population. In this case livestock management is an indicated control. Any factor that does not show any coordination with fly

Certain rules for chart interpretation have been helpful and have been found applicable in practice. When one or more factors absolutely prohibit the presence of the insects, no other factors can operate. When no factor absolutely inhibits the insect, all factors may be operative, and factors not represented may be operative. When no correlations are found, one or more effective factors are left out of the data, the insect census is faulty, or the data have factors counter-balancing

one another for each census period. The degree to which any factor limits an insect's population cannot be fully determined unless the degree of effectiveness of each and every other factor is known. Only absolute limitations of factors can be determined. When an absolute limit of any factor is determined and the factor can be controlled to that limit, the insect can be eradicated. The following is an example: In the study of the sticktight flea it was found that host material for the larvae was adult flea excrement (the absence of host material produces an absolute limit), and the moisture requirement in the larval breeding ground was very narrow (absolute limit, absence of the required amount of moisture in host material). Slight changes in equipment and management of poultry (controlling the moisture to the absolute limit in the host material) eradicated the flea in a yard, and decreased operating expense and increased production were obtained by these changes.

APPLICATION OF PLAN.—*The practical application of the plan* lies in obtaining the status of our insect populations and data on factors affecting these populations; these data to be used in civic, agricultural, and industrial planning to build up the most effective strategy to prevent establishment and increase of insect populations, and to control or eradicate established populations. Some pioneering has been done, but most of the work has been local and fragmentary. The most advantageous work at present would probably be the broad training of entomologists in the coordinate development of civics, agriculture, and industry. The demand for this work is rather urgent, as has been indicated in recent editorials in the Journal of Economic Entomology and in other places. Remarkable progress has been made in the insecticide field, both in research and in control operations, during the last 30 years. It is my belief that greater opportunities for research and applied entomology lie in the field of preventive entomology than have ever occurred in the insecticide field. Many of the required data have been accumulated by entomologists and members of other professions and trades, and are available for coordination in devising feasible insect control. No civic or industrial planning is complete that does not recognize the insect factor, neither is any plan for insect control complete that does not consider all civic and industrial factors affecting the plan.—5-2-40.

Biological Control of the Long-Tailed Mealybug, *Pseudococcus longispinus*[1]

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In the fall of 1933, immediately after the occurrence of a serious outbreak of *Pseudococcus longispinus*[2] (Targ.) over an area of about two hundred acres of oranges near Downey, Los Angeles County, California, the University of California Citrus Experiment Station began the introduction and liberation of parasites of *Pseudococcus longispinus*, under the direction of Professor Harry S. Smith.

Anarhopus sydneyensis Timberlake was introduced from Australia in 1933 and colonized in 1934. *Tetracnemus peregrinus* Compere was introduced from South America in the fall of 1934 and colonized in 1935. *Anagyrus fusciventris* (Girault) was introduced from Hawaii and colonized in 1936.

All these species became established and were recovered in the fall of 1939. At present their distribution appears to be limited rather closely to the points of colonization. The effect of these parasites on populations of *P. longispinus* on citrus is to some extent problematical because of other natural factors which operate to keep the populations in check. The 1933 outbreak on citrus was largely reduced by fumigation. It is significant that the orchard in which *Anarhopus sydneyensis* was first colonized on March

[1] Paper No. 414, University of California Citrus Experiment Station.

[2] *P. longispinus* is preferred to *P. adonidum* as the name of this species, since it is better known (Ferris 1918) and is now generally recognized (Green 1922). Cockerell (1922) points out that Linnaeus' description of *P. adonidum* apparently refers to some Monophlebid species.

6, 1934, was reported clean of *longispinus* in November, 1934, without having been fumigated.

DISTRIBUTION AND ECONOMIC IMPORTANCE OF *Pseudococcus longispinus* (TARGIONI).—The long-tailed mealybug, *P. longispinus*, is a cosmopolitan species attacking a wide variety of plants under tropical and subtropical conditions. Green (1917) found it to be the most widely distributed coccid in the plant houses of the Royal Botanic Gardens at Kew, England. Serious outbreaks of *P. longispinus*, however, appear to be uncommon. This may be a result of comparatively high inherent mortality and low effective rate of increase. Clausen (1915) found that the reproductive capacity and rate of increase of *P. longispinus* were very low, compared with *P. citri* (Risso), *P. maritimus* (Ehrh.), and *P. gahani* Green. He also observed that the mortality of the first instar larvae was much greater than in these species of mealybugs.

According to Arens (1915), a species of mealybug which he considered to be *P. longispinus* increased on coffee in Malay as a result of prolonged dry weather. In Italy, *P. longispinus* is held in check by winter temperatures (Berlese 1893). James (1937*b*), because of the "known partiality of *longispinus* for nearly all species of ferns," tried to propagate this mealybug on four species of ferns and found that it failed to thrive satisfactorily when enclosed under glass, apparently because of excessive moisture. When it attacks coffee or grapevines, the injury is largely confined to the clusters of berries (Arens 1915; de Castella & French 1929).

In Chile, Compere (1939) found *P. longispinus* abundant on various plants and injurious enough to be classed as a serious pest. And in a letter to Compere, dated May 8, 1934, Carl Schmidt, Research Fellow at the University of Hawaii says: "The past two years there have, been outbreaks of *Pseudococcus longispinus* [on pineapple] on the island of Lanai at about this time of the year, and I think that the probabilities are high that this is more or less of an annual affair."

In southern California *P. longispinus* sometimes reaches a severe density in late fall on dracaenas, its preferred host in the cool coastal districts. In certain parts of San Diego County it is a serious pest of the avocado. Before 1933, it had been found on citrus in the coastal areas (Smith & Armitage 1931) but had not been considered of much importance. In the outbreak on citrus at Downey the infestation was very spotted and there was considerable variation in the intensity of the attack on different trees in the same grove.

The wide distribution of *Pseudococcus longispinus* may be accounted for, in part, by the deposition of eggs by the female in more than one place; by the occurrence of oviposition at irregular intervals during a relatively long period of time; and by the rapid dispersal of the young, particularly when oviposition occurs away from the host plant (James 1937*b*). The eggs of *P. longispinus* hatch almost immediately after deposition.[3]

NATIVE HABITAT.—*Pseudococcus longispinus* has been so widely distributed for so many years that it is only on the basis of its low density and high parasitism that its native habitat can be ascertained. In Australia it appears to be less common than in other similar regions, and there it is attacked by *Anarhopus sydneyensis*, *Anagyrus fusciventris*, and *Coccophagus gurneyi* Compere.

Pseudococcus longispinus is known to occur in Australia from Gayndah, Queensland, to Mildura, Victoria. In the citrus orchards of Queensland it is seldom seen and never occurs in large numbers (Summerville 1934). The only native plants known to be hosts in Australia are *Acacia longifolia* (Froggatt 1921), *Microcitrus australasica* (Flanders 1934), and *Tristania conferta*. In Sydney in 1931, the last-named host was found to be generally but lightly infested.

Although *longispinus* has been reported as a pest of the grape in Australia (de Castella & French 1929; Flanders 1932), it is probable that the infestations followed applications of sulphur, a substance known to be inimical to parasitization by Hymenoptera. These infestations, which were observed during the fall of the year, were limited largely to the grape berries on a few vines here and there through the vineyards. De Castella & French (1929) in reporting the outbreak in a vineyard in Mildura, say: "It is curious that infested vines are not now more

[3] For details of the biology and external and internal anatomy of *Pseudococcus longispinus*, see Berlese (1893), Clausen (1915), and James (1937*a*).

numerous in the part first attacked than elsewhere in the vineyard. It would appear that some natural control is keeping it, at least partially, in check."

PARASITES OF *Pseudococcus longispinus*.—Seven species of primary parasites are recorded as being reared from *P. longispinus*. These are discussed briefly in the probable order of their importance; the most important first.

Anarhopus sydneyensis Timberlake.—This species was described from four females collected on citrus trees near Sydney, New South Wales, by Harold Compere in 1927 (Timberlake 1929). In 1931 I found it to be an effective parasite of *P. longispinus* on quince trees near Sydney. This discovery was facilitated by the fact that certain quince trees had previously been banded with burlap by a local entomologist, Luke Gallard, of Eastwood, New South Wales, employed by the U. S. Bureau of Entomology to collect parasitized oriental fruit moth larvae. Hundreds of parasitized mealybugs were collected from the burlap bands on the trunks of these trees (Flanders 1932). The hyperparasites, *Ophelosia crawfordi* Riley (Fig. 1A) and *Thysanus* sp. also were reared from these mummified specimens of *P. longispinus*. *O. crawfordi* is, in addition, predatory on the eggs of coccids (Smith & Compere 1931).

In April, 1931, an arrangement was made with Gallard to collect parasitized specimens of *P. longispinus*. On May 5, he collected 200 specimens; on May 25, 400; and on June 2, 200 specimens. These were forwarded at once to Riverside, California. Eighty adults reared from this material had a sex ratio of seven females to one male. Since at that time *P. longispinus* was not considered to be of economic importance, no liberations of this material were made.

The outbreak of *Pseudococcus longispinus* near Downey, in 1933, made it advisable to attempt again the introduction and establishment of *Anarhopus* on this host. Because of the knowledge obtained in Australia, in 1931, regarding Australian parasites of *P. longispinus*, and through the connections established there at that time, it was possible to import parasites *immediately* following the outbreak in California.

On August 8, 1933, a letter was sent to Gallard, requesting a shipment of parasitized mealybugs from the quince trees at Eastwood, New South Wales. A first shipment consisting of over 1,000 mummified mealybugs was received November 4, 1933. The parasites had issued from most of these mealybugs before they were collected by Gallard, and all except five females died en route. One of these parasites, which was an adult when the shipment arrived, was allowed to oviposit in *Pseudococcus longispinus* from November 5 to 7. She was then isolated in cold storage and, every three or four days, was taken out and fed on honey. The mealybugs that were parasitized by this female on November 5 and 6 mummified on November 18 and 19. On December 4, males of *Anarhopus* began to issue, and a total of twelve was obtained as the progeny of the one female. She was then removed from cold storage and mated with her offspring.

A second shipment was received on December 2, 1933, and consisted of six-

FIG. 1.—*Left, Ophelosia crawfordi* Riley (female); *center, Anagyrus fuscicentris* (Girault) (female); *right, Pseudaphycus angelicus* (Howard) (female). Drawings by Harold Compere.

teen mummified mealybugs, of which eight were in good condition. The mummies yielded six female parasites and one male. As the females emerged, they were mated and released in cages containing *P. longispinus* growing on potato sprouts. From the mated females, progeny of both sexes were obtained. These began issuing January 1, 1934.

The first field colonization was made March 6, 1934, when adults were liberated on orange trees infested with *Pseudococcus longispinus* in the Las Dos Palmas grove at Downey. On the same date, a small colony of *Anarhopus* was given to the Los Angeles County Insectary so that it could assist in the propagation and distribution of the parasite. On December 4, 1934, fifty individuals were released on dracaenas at the corner of Mountain Avenue and Pedregosa Street in Santa Barbara. In December, 1939, *Anarhopus* was recovered at Santa Barbara and in the vicinity of Downey. The mealybug in these localities appears to be held at a lower density than in areas where the parasite is not present.

Anarhopus has not been reared from any host other than *Pseudococcus longispinus*. Mating has been observed to take place only in the presence of *P. longispinus*. Under insectary conditions, the newly emerged female may oviposit immediately, but after several days appears to lose the urge to oviposit. Further details of the life history of the parasite are given by Compere & Flanders (1934).

Tetracnemus peregrinus Compere.—In 1924 and 1926 this species was reared from material imported into California from Cape Colony, South Africa. Ten years later it was collected in Brazil and Argentina by Compere (1939), who found it parasitizing *Pseudococcus longispinus*. *T. peregrinus* attacks the very small mealybugs. Masses of mealybug detritus containing countless mummified mealybugs were found on ferns growing in pots in the open-air patio of the American Embassy at Rio de Janeiro. Adult parasites were observed ovipositing in the live mealybugs which congregated on the new shoots. Parasitized *longispinus* were also collected in the Parque Lezica, Buenos Aires.

In the winter of 1934–35, several hundred adults of *Tetracnemus peregrinus* were reared from imported material received at Riverside. This species was propagated in the insectary. The females, however, appeared to lose the urge to oviposit a day or two after emergence. Liberations of the parasites were made as follows: 500 on dracaenas at the corner of Mountain Avenue and Pedregosa Street in Santa Barbara on December 4, 1934; 500 on two citrus trees at Rivera on October 31, 1934, March 30, 1935, and April 8, 1935; 150 on dracaenas in Balboa Park, San Diego, December 7, 1934; and 100 on dracaenas at 1335 Twenty-eighth Street, San Diego, March 17, 1935.

In December, 1939, *Tetracnemus* was recovered at the liberation points in San Diego, where it appears to be holding *P. longispinus* in check. As yet, this parasite has not been recovered from the other colonized areas where over 1,000 specimens were released. This may be the effect of competition with *Anarhopus;* for in these areas *Anarhopus* is the dominant parasite, although colonized in smaller numbers.

Since *Tetracnemus peregrinus* occurs in South America as well as in South Africa, it is possible that it has dispersed with its host and that, like *Anarhopus sydneyensis* and *Anagyrus fusciventris,* it originated in Australia. Compere informs me that in South America he reared *T. peregrinus* from *Pseudococcus gahani,* a mealybug native to Australia, where it is attacked by *T. pretiosus* Timberlake.

The biology of *Tetracnemus peregrinus* is similar to that of *T. pretiosus,* as reported by Clancy (1934). *T. pretiosus,* however, is not a parasite on *P. longispinus. T. peregrinus* can be distinguished readily from *T. pretiosus* by the relatively short first funicle joint (Compere 1939).

The hyperparasite *Thysanus* sp. and males of Coccophagus *gurneyi* were found to develop on *T. peregrinus* in Balboa Park, San Diego.

(3) *Anagyrus fusciventris* (Girault); syn. *A. nigricornis* Timberlake (Fig. 1, *B*).—In the fall of 1914, a female of this species was taken by sweeping at Tweed Heads, New South Wales. It became the type of the species (Girault 1915). *A. fusciventris* was not known to parasitize *Pseudococcus longispinus,* however, until Timberlake (1919) reared it experimentally in Hawaii. According to Timberlake, it is probable that *A. fusciventris* was purposely introduced into Hawaii by

Albert Koebele. It is possible that Koebele collected the parasite when, he visited Australia in 1904–1906. It was recovered in Honolulu by O. H. Swezey in 1910 (Timberlake 1919). In Australia in 1931, a few specimens of *A. fusciventris* were reared from *P. longispinus* on quince (Compere & Flanders 1934).

A. fusciventris has a wide range of hosts. Timberlake records *Pseudococcus gallicola, P. montanus, P. lounsburyi*, and *Ripersia palmarum*. It attacks the mature individuals.

At the suggestion of Professor Harry S. Smith, a letter was sent to Swezey, asking whether he knew where *Anagyrus fusciventris* could be obtained in Hawaii for introduction into California. Two sendings of parasitized *P. longispinus* to California were made by Walter Carter, of the Hawaiian Pineapple Canners Association Experiment Station, Honolulu. From the second shipment, received at Riverside on April 11, 1936, a small breeding stock of *A. fusciventris* was obtained, and the species was successfully propagated in the insectary. The development of each generation required about 24 days. Although in the field this parasite appears to be less efficient than either *Anarhopus* or *Tetracnemus*, it is the easiest to propagate in the insectary.

Small colonies were released on dracaenas in front of the old post office at San Diego, in a nursery at Otay, about 15 miles from San Diego and on citrus at the San Joaquin Fruit Company in Orange County.

In December, 1939, *Anagyrus fusciventris* was recovered at Otay. As in Hawaii, it appears to have had little influence on the population of *Pseudococcus longispinus*. A female of *Achrysopophagus* sp. emerged from parasitized mealybugs collected at Otay. This species is probably hyperparasitic on *A. fusciventris*.

Coccophagus gurneyi Compere.[4]—This aphelinid was reared from *Pseudococcus longispinus* collected in 1927 on citrus near Sydney, New South Wales, by Compere (Compere and Smith, 1932). In 1931, I reared *C. gurneyi* from *P. longispinus* on *Tristania conferta* in Sydney.

In the fall of 1939 a number of specimens of *P. longispinus* on dracaenas near San Diego and at Santa Barbara, California, were observed to be parasitized by *C. gurneyi*. The percentage of parasitism in the field, however, was low. Bess (1939) found experimentally that a large percentage of individuals of *P. longispinus* were susceptible to *C. gurneyi*, but that the majority of *C. gurneyi* larvae gradually disintegrated within the body fluids of the host.

Leptomastix dactylopii Howard.—According to Compere (1939), "*Leptomastix dactylopii* was described by L. O. Howard from specimens reared in 1884 from *Pseudococcus citri* (Risso), infesting *Paeonia* on the grounds of the Department of Agriculture, Washington, D. C. Howard stated that the mealybug infestation was completely destroyed by this parasite. Later he reported that *L. dactylopii* had been collected on St. Vincent in the British West Indies in 1894. In the collection of the Citrus Experiment Station is a series of specimens determined as *L. dactylopii*, reared from *P. citri* on figs, taken by W. E. Bradley at Baton Rouge, Louisiana, October, 1923."

Leptomastix dactylopii now appears to be established in California from a single pair imported from Rio de Janeiro in 1934. This parasite attacks mature mealybugs. Bess (1939), in experiments at Riverside, was able to rear *L. dactylopii* on *P. longispinus*, although a majority of the parasitic larvae died before completing their development.

In Rio de Janeiro, Compere (1939) found occasional mature *P. longispinus* that had been mummified by the action of a large internal parasite which was possibly *L. dactylopii*.

Pseudaphycus angelicus (Howard) (Fig. 1, *C*).—This gregarious encyrtid is recorded as being reared in considerable numbers from *Pseudococcus longispinus* collected at Santa Barbara, California. Other hosts are *Pseudococcus maritimus, P. gahani*, and *P. ryani* (Clausen, 1924). C. J. Joubert reared *Pseudaphycus angelicus* from *Phenacoccus gossypii* (Flanders 1935). Species *Phenacoccus* appear to be the preferred hosts of this parasite.

Acerophagus nubilipennis Dozier.—A female of this encyrtid was reared by Dozier (1926) from *Pseudococcus longispinus* collected from elephant ear in Puerto Rico. A specimen was also reared from *P. citri*.

[4] The introduction of *Coccophagus gurneyi* Compere and *Tetracnemus pretiosus* Timberlake into California for the control of *Pseudococcus gahani* resulted in the most satisfactory biological control of a serious pest in the history of California.

SUMMARY.—As a result of an outbreak of long-tailed mealybug, *Pseudococcus longispinus* (Targioni), on citrus in Los Angeles County, in 1933, three parasites, *Anarhopus sydneyensis* Timberlake, *Tetracnemus peregrinus* Compere, and *Anagyrus fusciventris* (Girault), were introduced and established in southern California. These parasites are not, as yet, widely distributed. *A. sydneyensis* and *T. peregrinus* appear to be effective in maintaining the populations of *P. longispinus* at low densities. *Anagyrus fusciventris* seems to be of little, if any, importance.

On the basis of low density and high parasitisim, it is concluded that Australia is the native habitat of *Pseudococcus longispinus*—4-3-40.

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Effect of Temperature upon the Toxicity of Stomach Poisons

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It is well known that the median lethal concentrations of fumigants and contact poisons are influenced by temperature. In general and within limits, the higher the temperature the lower the M.L.C. For stomach poisons, however, it is not known in any instance whether temperature affects the median lethal dose. The purpose of this investigation is to find out what effect, if any, temperature may be expected to exert on the toxicity (M.L.D.) of inorganic stomach poisons to lepidopterous larvae.

Materials.—Fifth instar larvae of the southern armyworm, *Prodenia eridania* Cram., and the velvetbean caterpillar, *Anticarsia gemmatilis* Hbn., were used as the test insects. Only larvae that had just gone into the last instar were used in order that none of the caterpillars would pupate during the course of the experiment. The southern armyworm larvae were reared in the laboratory by well-known methods, and were fed on soybean foliage. The velvetbean caterpillar larvae were collected from infested soybean fields.

The insecticides used in this investigation were fresh samples of proprietary products. A given sample of each material was used throughout the experiment. A chemical analysis of the cryolite was supplied by the Aluminum Ore Company. The arsenicals were analyzed by J. L. Farr, Assistant Chemist, and reported by A. P. Kerr, Chief Chemist, Louisiana Agricultural Experiment Station. The analyses of the materials are as follows:

Calcium arsenate. This sample contained 42.11 per cent As_2O_5, .15 per cent water soluble As_2O_5, 44.00 per cent CaO, and 1.06 per cent moisture.

Acid lead arsenate. This sample contained 32.53 per cent As_2O_5, .63 per cent water soluble As_2O_5, 66.90 per cent PbO, and .08 per cent moisture.

Basic copper arsenate. This sample contained 38.90 per cent As_2O_5, .15 per cent water soluble As_2O_5, 55.17 per cent CuO, 44.04 per cent Cu, and .25 per cent moisture.

Synthetic cryolite (Alorco). This sample contained 85.3 per cent cryolite, 3.8 per cent Al_2O_3, 7.6 per cent loss on ignition, and 3.3 per cent normal impurities.

Methods.—The constant temperature rooms in which the investigation was conducted were sufficiently large so that all the work, including the weighing and feeding of the larvae, was done at the particular temperature desired. In other words, the larvae were not removed from the constant temperature rooms from the time they were placed there until the experiment was completed.

The single leaf method of Hansberry & Richardson (1936) as modified by Ellisor & Floyd (1938) was used for feeding measurable doses of stomach poison insecticides to caterpillars. The method of applying the sticker material to the leaf square as described by Ellisor & Floyd (1938) was not used in this investigation, since the pubesence of the soybean leaf readily retained the insecticide.

Two changes in the method of feeding the larvae proved quite useful. Petri dishes, the bottom covered with a layer of paraffin, were used to carry the dusted leaf squares from the dusting tower to the constant temperature rooms. A piece of celluloid of the same shape as the leaf square but slightly smaller was first placed on the pin. The pin was then pushed through the leaf square, which was already on the paraffin, and adjusted to within one-eighth of an inch of the celluloid square. After the leaf square was put on the pin, a one-fourth inch square of stiff paper was adjusted to within one-sixteenth of an inch of it. The pin was then stuck into packed sand to within about one-fourth inch of the leaf square. This arrangement forced the caterpillar to remain either on the sand or on the celluloid while feeding, and too, forced it to feed on the edges, thus preventing the larva from eating to the pin on one side and dislodging the leaf square before consuming the required amount of leaf area.

Ten-millimeter leaf squares were used. Instead of using the flexible cross section millimeter paper, a tin plate 50×100 mm. was dusted with the leaf squares in the dusting tower by the air-float method. This method was described in a previous paper by Ellisor & Floyd (1939). The leaf squares were placed on the plate-like base of the dusting tower surrounding the tin plate. The weight of the tin plate was determined before and after dusting, the difference in weight being calculated as

* Died October 21, 1939.

the amount of dust falling on 5,000 square mm. By dividing the weight of the dust on the plate by 5,000 the amount on one square millimeter was obtained.

After placing the leaf squares on the packed sand, as already described, a larva was put on the sand by each leaf square and capped with a celluloid cup. The caterpillars were observed closely until the approximate number of calculated squares desired were consumed.

The partly eaten leaf squares were removed and the amount eaten measured by a device made by Ellisor & Floyd (1938). This device consisted of a cross-section of millimeter paper glued onto a block and covered with a piece of celluloid having a 10 mm. square cut out of it so that the leaf square fitted down onto the graph paper. A strip of celluloid held the leaf square in place while the number of squares eaten were counted with a binocular microscope.

In all cases, the caterpillars were weighed, numbered, and deposited in celluloid cups containing fresh food immediately after feeding on the dusted squares, and examined at regular intervals. The criterion of effect in all cases was true death. In past studies, it was observed that larvae poisoned by any of the common stomach poisons usually recovered after they had once begun feeding normally although the larvae may have remained inactive for several days before they fed or died. Therefore, the larvae used in this experiment were retained on fresh food until they either recovered or died.

All the tests were run at 60 and 80 degrees, and in each case the caterpillars were kept at the particular temperature at which they were to be fed for at least 12 hours before the poisoned leaf was given to them. This permitted the larvae to become acclimated to the particular temperature at which they were to be fed.

It was observed that the velvetbean caterpillar larvae were much more active at 60 degrees than were the larvae of the southern armyworm. However, both species fed fairly well at 60 degrees. Both species were very active and fed readily at 80 degrees.

The data obtained in this study are presented in Table 1.

Table 1.—The effect of temperature upon toxicity of four stomach poison insecticides.

Insecticide	Insect	Temperature	Number Insects in the Intermediate Zone	Dosage Range	Mean Survival Period	M.L.D.
				mg./g.	*hours*	*mg./g.*
Synthetic cryolite	*A. gemmatilis*	80°F.	98	0.08–0.18	38	0.13
Synthetic cryolite	*A. gemmatilis*	60°	93	0.08–0.22	42	0.13
Acid lead arsenate	*A. gemmatilis*	80°	73	0.07–0.15	31	0.11
Acid lead arsenate	*A. gemmatilis*	60°	79	0.04–0.13	40	0.06
Calcium arsenate	*A. gemmatilis*	80°	116	0.05–0.19	36	0.10
Calcium arsenate	*A. gemmatilis*	60°	137	0.03–0.15	42	0.06
Basic copper arsenate	*A. gemmatilis*	80°	126	0.06–0.26	29	0.14
Basic copper arsenate	*A. gemmatilis*	60°	134	0.04–0.16	42	0.11
Synthetic cryolite	*P. eridania*	80°	148	0.38–1.01	27	0.55
Synthetic cryolite	*P. eridania*	60°	71	0.19–0.55	45	0.33
Acid lead arsenate	*P. eridania*	80°	91	0.07–0.28	19	0.14
Acid lead arsenate	*P. eridania*	60°	46	0.07–0.14	37	0.09
Calcium arsenate	*P. eridania*	80°	67	0.09–0.26	20	0.16
Calcium arsenate	*P. eridania*	60°	145	0.03–0.13	28	0.07
Basic copper arsenate	*P. eridania*	80°	128	0.09–0.19	22	0.13
Basic copper arsenate	*P. eridania*	60°	126	0.07–0.15	28	0.10

DISCUSSION OF RESULTS.—As indicated in Table 1, the M.L.D. of all the insecticides used in these tests for both the velvetbean caterpillar and the southern armyworm was lower at 60 than at 80 degrees with one exception; the M.L.D. of cryolite for the velvetbean caterpillar was the same at the two temperatures. However, temperature did have a noticeable effect on cryolite for the southern armyworm, for which the M.L.D. was

lowered from 0.55 mg./g. at 80 degrees to 0.33 mg./g. at 60 degrees.

With two of the insecticides, there was an equal drop in the M.L.D.'s between the two temperatures for each species: 0.05 mg./g. for lead arsenate and 0.03 mg./g. for basic copper arsenate.

The survival periods were shorter at 80 than at 60 degrees, the difference ranging from 4 to 18 hours. The greatest difference (18 hours) in survival period occurred when the southern armyworm was fed cryolite and acid lead arsenate.

Although there was little difference in the toxicity of basic copper arsenate to the two species, great difference existed in the toxicity of the other insecticides. The greatest difference was found with cryolite, where the M.L.D. was 0.55 mg./g. for the southern armyworm at 80 degrees and only 0.13 mg./g. for the velvetbean caterpillar at the same temperature. Except basic copper arsenate, all the insecticides were more toxic to the velvetbean caterpillar than to the southern armyworm.

Apparently as the metabolism of the insect was slowed down by the lower temperature, the effect of these stomach poisons could not be thrown off so readily; hence it required less poison but more time to kill at the lower temperature.

SUMMARY.—An improved technique for feeding the caterpillars in determining the M.L.D. is described. Fifth instar larvae of the velvetbean caterpillar and the southern armyworm were used as test insects. The tests were conducted at 60 and 80 degrees. A total of 16 M.L.D. were determined at the two temperatures and with four insecticides: synthetic cryolite, acid lead arsenate, basic copper arsenate, and calcium arsenate. In all instances, except one, the insecticides were more toxic at 60 degrees than at 80 degrees; however, the mean survival period was shorter at 80 than at 60 degrees. All the insecticides tested were more toxic to the velvetbean caterpillar than to the southern armyworm, except basic copper arsenate, which showed very little difference.—4-29-40.

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An Airplane Survey of Green Bug* Injury in Oklahoma

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On March 27, 1939, green bug infestations in southern Payne County near Stillwater, Oklahoma, reached such serious proportions that a number of fields of barley were almost entirely destroyed and numerous other fields of both wheat and barley were suffering severe injury. Since the outbreak had become severe so early in the season, it appeared that very serious trouble might soon develop.

Experiment Station and Extension officials decided that a survey should be made at once to determine the severity and extent of the infestation. An airplane survey appeared desirable so the information would be available quickly. A trial flight the previous day had indicated this method to be practical, quick, and inexpensive. A project was therefore set up to conduct such a survey. The Director of the Extension Division assumed the responsibility for financing the project; and the senior author, because of previous experience, was selected to make the survey.

The manager of the local airport agreed to furnish the airplane and do the piloting at a rate of $6.00 per hour for a two-place plane having a cruising speed of 75 to 80 miles per hour, or $10.00 per hour for a four-place plane having a cruising speed of 100 miles per hour.

APPEARANCE OF GREEN BUG INFESTATIONS.—Green bug infestations typically start in small spots in the late winter or

* *Toxoptera graminum* Rondani.

early spring in grain fields. As the population increases, the grain turns yellow in color and soon dies. The green bugs then crawl to the periphery of the circle thus formed, where they continue to feed and multiply. This results in a constantly widening circle of dead grain surrounded by a ring of bright yellow[6] and immediately outside of this the grain is green (Fig. 1). Such an appearance is so characteristic of green bug infestation that it is very readily diagnosed and can be seen for a considerable distance, particularly if one is sufficiently high to obtain a good view of the field.

The trial flights showed that only under unusually favorable circumstances could all the above mentioned characteristics be seen from an altitude of 500 feet, which is somewhat lower than is considered safe for cross country flying. Where a heavy growth of grain and a severe green bug infestation occurred together, the yellow ring was plainly visible at an altitude of 500 feet; but such a condition only rarely existed in this area so early in the season. Field glasses were tried on a subsequent flight but it was found that the slight vibration of the plane, multiplied by the power of the glasses (8 power), resulted in a slight blur and that better vision could be obtained with the unaided eye. By visiting infested fields on the ground, both before and after flights over them and by inspecting on the ground other fields concerning which

FIG. 1.—Typical early season green bug injury.

there was doubt while flying over them, it was found that sufficient other characteristics could be seen to make identification reasonably certain.

APPEARANCE OF DAMAGE FROM HIGH ELEVATIONS.—The greatest difficulty encountered consisted of distinguishing green bug infested spots from bare spots due to other causes, particularly soil conditions. Bare spots were present in a great many of the fields inspected and all could readily be seen from the air. The characteristics of green bug spots that

FIG. 2.—Aerial view of grain field with light green bug infestation.

were depended upon for identification were as follows:

1. Green bug spots are typically more nearly circular than bare spots due to other causes (Fig. 4). Thus, if a number of spots due to soil conditions, moisture deficiency, etc., are present in a field, few if any, are circular, while in infested fields nearly all of the spots are more or less circular.

2. In most spots other than those caused by green bugs (Fig. 3.) green points extend out into the spots and frequently green areas are found within them. Neither of these is typically present in green bug spots.

3. The dead grain within the circle gives green bug spots a characteristic color not found in spots where grain has never grown.

CHECKING DOUBTFUL INFESTATIONS.—After these points had been determined, it was only occasionally that spots were found concerning which there was much doubt. It was found that in these instances definite diagnosis could be made by flying extremely low over the questionable spots. In making such an inspec-

FIG. 3.—Aerial view of grain field with spots due to causes other than green bugs. Note difference in appearance as compared to Figs. 2, 4 and 5

tion the plane was headed into the wind and a descent made as though a landing were to be made slightly beyond the questioned spot. The plane was maneuvered into such a position that the spot was about 15 feet to one side of the observer at the time the plane reached a height of 6 to 8 feet from the ground. The landing speed of the smaller plane used was approximately 35 miles per hour, so that when this was reduced by the wind in the above maneuver the speed was sufficiently slow so that an adequate amount of detail was observed, and doubt no longer existed concerning the presence or absence of green bugs. After the spot was passed, the motor was

FIG. 4.—Aerial view of grain field with medium green bug infestation.

speeded up to climb back to a cruising height.

PROCEDURE OF SURVEY.—Before starting the survey the pilot was given a map with the suggested route mapped on it and instructed to fly near this route or to the right or the left of it, providing more grain fields could be observed by so doing. Detailed outline county maps of each county to be surveyed were also used. The pilot, in addition to piloting the plane, constantly mapped the route flown, and thereby our location at all times was known. An altitude of 1,000 to 1,500 feet was maintained most of the time. When an infested field was found, a dot was placed in the proper part of the section in which it occurred and numbered 1, 2, or 3, according to whether the infestation was light, medium or heavy. The following criteria were used in assigning numbers to infested fields: A light or number 1 infestation was a field in which the spots were small and few in number (Fig. 2). A medium or number 2 infestation was one in which some spots had become quite large or small spots were scattered over a considerable portion of the field (Fig. 4) and a heavy or number 3 infestation was one where the spots had begun to coalesce or approximately 25 per cent or more of the field was heavily infested (Fig. 5).

FIG. 5.—Aerial view of grain field with heavy green bug infestation.

ESTIMATING INFESTED ACREAGE.—The acreage of each infested field was also estimated and recorded. Such an estimate may be made with considerable accuracy by estimating the percentage of a section, half-section, or quarter-section in the field (Fig. 6). When one can see the entire section and the quarter-section lines, this is a comparatively simple task. The greatest error occurring in this part of the work was where infested fields were too numerous to record all accurately in the time required to fly over them.

INFESTATIONS FOUND.—The routes flown, dates, time required, and approximate location of infested fields found are shown in figure 7. The flights made March 30, 31 and April 14 were made in the slower two-passenger plane and the one made April 1 in the four-passenger plane with two additional observers. From this experience it was concluded that the smaller plane was the more practical to use for such a survey.

Figure 8 is the map of infestation prepared April 4 from the data then available. It should be noted that this map was prepared without the data taken on April 14. An estimated total of 15,720 acres of infested grain was observed divided as follows: light infestation 2,875 acres, medium infestation 5,790 acres, and heavy infestation 7,055 acres.

At the close of the outbreak questionnaires were sent to each county agent requesting information concerning the amount of damage resulting from green bug infestation. Figure 9 summarizes the estimates of injury obtained by this method. Any one familiar with the routine duties of a typical county agent will recognize at once that this is but a rough estimate, but it is thought that in general it furnishes a fairly accurate picture of the situation.

For purposes of comparison the map of early infestation has been superimposed upon the map of final damage.

FIG. 6.—Aerial view illustrating how acreage of fields may be estimated from the air. X marks center of Section. Fields numbered 1 are one-half of quarter sections and therefore contain 80 acres. Fields 2 and 3 together contain 80 acres, but divided so that field 2 contains approximately 35 acres, and field 4 45 acres. Fields 4, 5 and 6 also contain 80 acres. No. 4 contains 40 acres and 5 and 6, 15 and 25 acres, respectively.

It may be noted that while the predicted injury was not correct in a number of areas, still, on the whole, the forecast was surprisingly accurate. Considering the fact that the survey was conducted without the benefit of previous experience, the final estimate of injury checked more closely with the predicted injury than was expected. It is also believed that the experience obtained should enable one to avoid in future surveys certain errors made in this one.

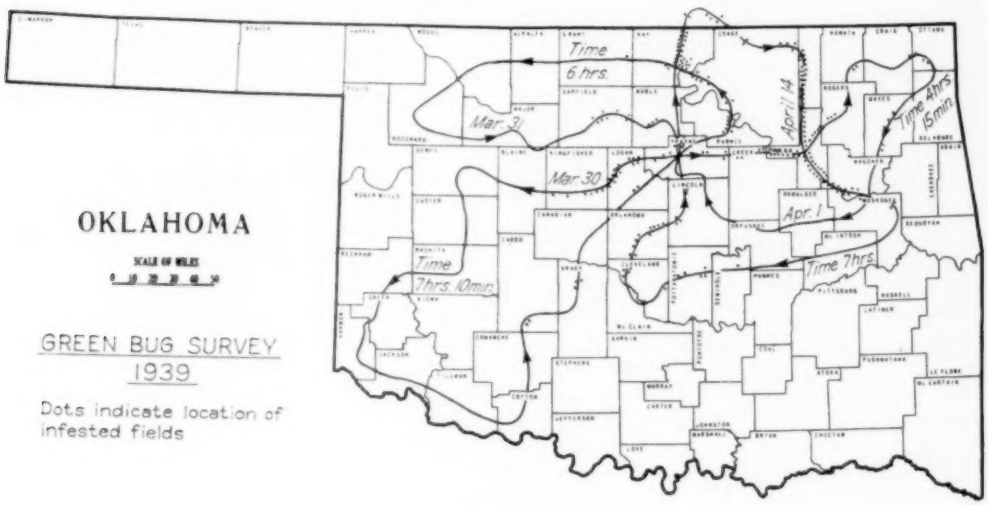
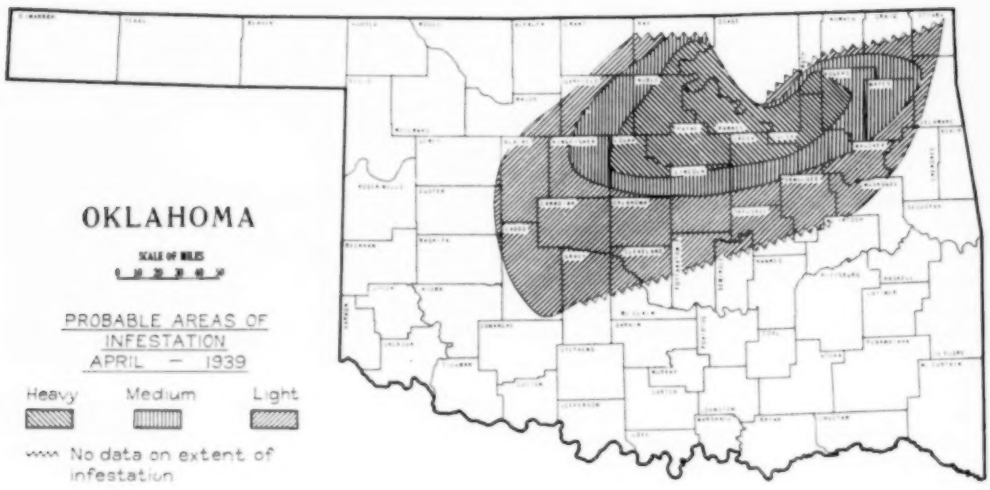


FIG. 7



RESULT OF GREEN BUG SURVEY, MARCH 29-APRIL 1

FIG. 8

COST OF SURVEY.—The light plane was used for a total of 20 hours and 10 minutes at a cost of $121.00, the larger plane 4 hours and 15 minutes at a cost of $42.00. Thus, the total expense for the planes for the four trips was $163.50. The per mile cost of the light plane was slightly over eight cents and that of the larger plane approximately ten and one-half cents.

ADVANTAGES OF AERIAL SURVEY.—After having completed such a survey, it is the opinion of the writers that, under conditions where such a survey is practical, it has definite advantages over surveys made by car. Among them are the following: First, such a survey can be completed much more quickly than by car. In this case it was March 27 when the seriousness of the outbreak became apparent. The survey was started March 30 and the data from which the forecast was made were completed two and one-half days later, which happened to be Saturday at noon. The data were compiled and assembled for mimeographing that afternoon and the map was mimeographed the following Monday, April 3. On April 4, copies were mailed to all county agents in the wheat growing sections, to entomologists of the other states of the middlewest, and to the Bureau of Entomology and Plant Quarantine at Washington, D. C. Thus five and one-half days after the discovery of the outbreak we had a fairly accurate picture of the situation, and within two and one-half additional days this information was available to practically all interested parties. With the experience gained in the undertaking it is believed that in the future this time could be reduced 50 per cent and still greater accuracy attained.

Second, more thorough inspections can be made. Numerous infested fields were found from the air that had been missed by other workers who drove over portions of the route taken in the aerial survey. The uneven nature of the area surveyed largely explains this. A person driving along the road can seldom view an entire field, even though it adjoins the road; and even less frequently can he view those one-fourth or one-half a mile away. From the air it is possible to see all of every field for at least a mile in each direction. Heavily infested fields were frequently detected at a distance of two or three miles. It seems probable that a person in a car would have to drive around at least three sides of a section in order to get even approximately as good a view of it as one obtains from the air.

Third, more efficient routes can be chosen. Unless one is exceedingly familiar with the country and the crops in it, it probably is not possible to choose a route that would bring one in view of the greatest number of fields to be inspected

with the least amount of driving. From the air one may look miles ahead and choose the best route, avoiding areas where the desired crops are not located. This is especially true in the early spring when small grain fields constitute most of the green colored fields.

Fourth, it is a much cheaper method. The factors discussed above explain this statement to a considerable degree. The present rate paid in Oklahoma for driving a personal car is 4 cents per mile. The per mile cost of this survey was approximately 9 cents per mile. For reasons already stated, a car would have to be driven at least three times as far to obtain comparable information. Thus, the transportation expense by air was 9 cents as compared to 12 cents by car. To this must be added the additional time and hotel expense required in making a survey by car. The greater efficiency in selecting a course from the air still further widens the gap between the expenses involved in the two methods. It seems probable that the car method would cost twice as much as by air. Until one has both flown over and driven a car through the same territory looking for material on the ground, it is difficult to conceive how much more efficiently one can see things from the air, provided of course, they are sufficiently large to be seen from a considerable height.

POSSIBLE CONTROL OF GREEN BUG.—The general belief among farmers and entomologists at present is that little or nothing can be accomplished to control green bugs. However, the information obtained on this survey, together with observations made during this and past outbreaks, suggests a possible control.

Most attempts at control in the past have consisted of destroying green bugs by sprays, dusts, burning or plowing. These measures have been attempted on a small scale, usually after some injury has occurred and after the green bug populations have built up to tremendous proportions. Under such circumstances, even though the green bugs in any particular place may be killed, the insects drifting in from the surrounding area soon heavily reinfest the treated fields.

It seems reasonable to assume, however, that the most of the damage might be avoided, if infestations were located sufficiently early so that they could be stamped out easily. It is the writer's belief that an aerial survey constitutes a rapid and inexpensive method of locating infestations in their incipient stages. On numerous occasions spots no larger than a yard in diameter were located. These facts suggest the possibility of an earlier survey. Probably in February when infested spots are small, followed by a ground crew to bring all infestations under control. The location of such infestations while still small may sufficiently reduce the time and expense of control measures to render such a practice

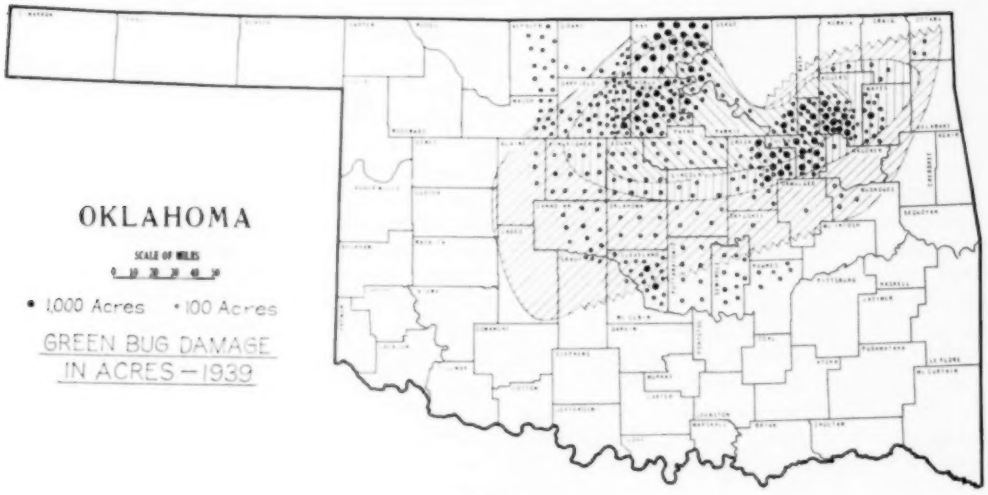


FIG. 9

feasible. The fact that green bugs are thought to be carried by air currents from the southern part of the wheat belt into the Dakotas and Minnesota may make the above statement appear illogical. However, when such migrations occur they are always in a northerly direction into an area where crop development is later. For serious injury to occur, the comparatively small numbers that migrate north must have enough time to build up large populations before the grain becomes sufficiently mature to resist them. Past observations indicate that if the initial infestations within the endemic area could be largely stamped out, the grain within this area would become too mature for serious injury to occur before the green bug population could again build up to serious proportions. This in turn should sufficiently delay the building up of large populations so that northward migrations would occur too late for serious injury to occur north of the area where the green bug is endemic.—1-6-40.

Observations on *Cirphis unipuncta* Haworth in Mississippi

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Insect records since 1900 indicate that the true armyworm, *Cirphis unipuncta* Haworth, was of no economic importance in Mississippi until 1931 when a destructive outbreak occurred on oats in the Delta section. In 1937 and again in 1938 the same crop in the same area was severely damaged. Since very little has been published about the biology of this insect in the South, this brief summary of a few observations on its life history in Mississippi is presented.

WINTER ACTIVITY OF MOTHS.—At State College, Mississippi, moths were caught in light traps during favorable weather throughout the winter of 1938–1939. Oviposition on oat plants outdoors usually occurred within two to three days. Moths caught November 24 oviposited the same day and the following day, with minimum temperatures of 31 and 24 degrees respectively, the latter being the lowest temperature at which oviposition was observed. Another moth caught December 4 oviposited December 6 with a minimum temperature of 31 degrees. A moth caught February 14 began laying February 20 and continued over a period of 10 days until March 2. The average minimum temperature for this period was 36 degrees with a low of 22.

INCUBATION PERIOD.—The time required for eggs to hatch varied from 2 days in July with a mean temperature of about 86 degrees to 35 days in December and January with a mean minimum temperature of 38 and a low of 18 degrees. In August, incubation required 3 days, in May 4 days, in October 6 days, in March and February from 10 to 25 days. For example, eggs laid February 20 required 25 days to hatch while eggs from the same moth laid March 2 required only 18 days. Eggs laid March 15 hatched in ten days.

LARVAL PERIOD.—The larval period showed little variation during the summer, averaging 20 days in May, 21 days in July and 18.5 days in August. An October group of larvae averaged 26.5 days. Larvae hatching during November, December and January made very slow growth except during periods of warm weather and those under observation passed the entire winter in the larval stage. Larvae which hatched November 22 reached the third instar by January 9 and pupated March 20. Larvae hatching January 10 molted for the first time February 14 and with later warm weather became full grown by March 22.

PUPAL PERIOD.—The pupal period ranged from 10 to 15 days in summer and from 32 to 57 days in midwinter. However, the pupae in this winter record were in pill boxes kept on an open porch with a northeastern exposure and were exposed to greater extremes of temperature than occurred in the soil. Others from the same group of larvae pupated in the ground on the north side of a building in a rather shaded location and remained in the pupal state throughout the winter, the first moth emerging March 21.

OVERWINTERING STAGES.—Since 1861 the winter stages of this insect have been

the subject of much speculation. The early hypotheses of C. V. Riley and others make interesting reading but time will not permit discussing them. John B. Smith (1896), reporting his observations in New Jersey, stated:

> I feel certain the insect may pass the winter in any except the egg stage. I have found the moth during the entire winter in sheltered situations, and have found, very late in fall, caterpillars of all sizes and newly-formed pupae.

H. H. Knight (1914) reported that pupae did not survive the winter in New York. Davis & Satterthwait (1916) found only partially-grown larvae surviving in Indiana.

In Mississippi all stages of the insect have been observed throughout the winter. Moths were flying and ovipositing at temperatures considerably below freezing. Eggs hatched and larvae developed all during the winter. Those hatching in October passed the winter as pupae, while those hatching in November, December and January remained in the larval stage until spring. In extremely cold winters the pupae are probably killed just as in states farther north, while in very mild winters larvae may develop rapidly and pupate in midwinter. The moths caught in light traps during the winter could have come from farther south or might have emerged locally, for pupae exposed in pill boxes to the extreme fluctuations of the weather produced adults in midwinter after surviving two separate cold spells when the temperature dropped to 20 and 18 degrees, respectively. Conceivably, pupae in sunny soil locations or during very mild winters might produce adults any time during the winter.—1-9-40.

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Control of the Alfalfa Snout Beetle, *Brachyrhinus ligustici* (L.)

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During the past four years measures for the control of the alfalfa snout beetle, *Brachyrhinus ligustici* (L.), have been studied in Oswego and Jefferson counties of northern New York. Scouting activities conducted by the New York State Department of Agriculture and Markets have shown some three thousand acres of alfalfa and clover to be infested in these two counties. Because the known distribution of this pest is still limited to this area all investigations on *B. ligustici* have been carried on under strict voluntary quarantine within the infested region.

In 1935, 1936, and 1937 the adult beetles began active migration during the last four days in April; in 1938 migration began much earlier, on April 18. Prior to emergence and active migration the beetles may be hidden under trash and within the first two inches of soil for as long as two weeks, while awaiting favorable surface temperatures. If the beetles are warmed up during this time they will feed, making it possible to carry on bait tests in the laboratory. The first field applications of bait should be made as soon as active migration and feeding begins. A discussion of cultural practices that aid in the control of this insect will not be included in this paper.

CONTROL EXPERIMENTS.—In 1935 preliminary tests in small field plots indicated that raisin-shorts* bait (Palm, 1936) was effective against the adults of *B. ligustici*. This bait consists of 50 pounds of raisins, 50 pounds of shorts and 5 pounds of sodium fluosilicate. (Downes, 1932) The raisins are soaked for at least two hours and the excess water drained off. The shorts and sodium fluosilicate are mixed dry and added to the raisins. This mixture is then ground twice through a food chopper. In the subsequent three years this bait has given a high degree of kill in experimental plots and has been used

* Shorts is also known as standard wheat middlings.

with good success by the New York State Department of Agriculture and Markets in a control campaign on all known infested fields. At the time of application, in late April and early May, temperatures are quite low and feeding occurs only in the daytime on warm days when usually

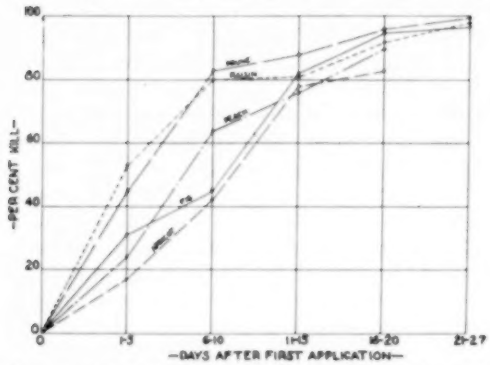

FIG. 1.—Control of the alfalfa snout beetle with various fruit-shorts-sodium fluosilicate baits in 1937.

there is a bright sun which may dry out the bait and make it unpalatable. Often after an application of bait there will be days of cold rainy weather. If a bait cannot retain good physical qualities and be attractive to the beetles after such weather, it is ineffective.

In 1936, cracked corn, apple pomace, and ground oats in combination with honey were tried in bait mixtures in comparison with raisin-shorts. These materials were soaked until thoroughly moist, all the water drained off, and the honey added at the rate of 20 pounds to 100 pounds dry weight of the carrier. Sodium fluosilicate at the rate of 5 pounds per 100 pounds of the carrier was used as the poison. While none of these baits was a satisfactory substitute, there was some indication that honey was attractive to the beetles.

In 1937 and 1938 baits were mixed substituting dried peaches, apricots, dates, prunes, and figs for the raisins in the standard raisin-shorts bait. Figure 1 presents the results of counts made in quarter-acre field plots in alfalfa sod receiving three applications of bait in the spring of 1937. Each application was at the rate of one bushel of bait per acre. Approximately 50 beetles were counted at random every day in each plot and are presented as averages for five-day periods. Prune and raisin baits were slightly more efficient than peach, fig, and apricot but the differences were not great.

In 1938 a series of tests were made in 3 by 4 foot plots on plowed ground and in alfalfa sod. One hundred beetles were liberated in each plot at the time the bait was spread. Counts were made two days later on plowed ground and three days later in alfalfa. Figure 2 presents the efficiency ratings of the fruit baits as compared with the standard raisin bait in these small plots and in cages in an incubator at 70 degrees F. One hundred beetles were used with each bait in the cages. In calculating this efficiency rating the per cent kill obtained with standard raisin bait was divided into 100. The per cent kill with each of the other baits in the same experiment was multiplied by the quotient to get the efficiency rating. Fig bait was less efficient than raisin, prune, date, peach or apricot baits but not significantly so.

In 1937 crushed corncobs, beet pulp, grape pomace, apple pomace, sawdust, cracked corn, and ground oats were used as carriers in combination with stock molasses, honey, white mineral oil and stale beer. Of these materials molasses was not attractive and the oil was repellent. Some success was obtained with the honey bait but it was still decidedly infe-

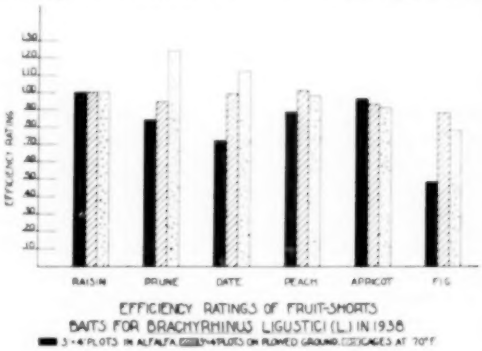

FIG. 2.—Efficiency ratings of fruit-shorts baits in 1938.

rior to the standard raisin bait. Stale beer was quite attractive but did not remain so for a very long time.

Beetles for use in laboratory bait tests in 1938 were collected from naphthalene barriers and stored in large cages. Twenty-five beetles were placed with a small handful of the bait in each cage. In some of the early tests, alfalfa foliage was also

added. Since the foliage made the results more variable and caused greater difficulty in counting the beetles, it was left out in later tests. The cages were kept in an incubator at 70 or 75 degrees. Usually counts were made at 12 and 24 hours, and sometimes after longer periods. When a beetle failed to show response to the pressure of a pencil-point on the venter of its abdomen, it was considered dead.

Several baits were devised which compared quite favorably with standard raisin bait, both as to physical qualities and attractiveness to the beetles. In the preliminary tests made in cages at 70 degrees, crushed corn cobs, cracked corn, and bran were used more or less interchangeably as carriers. In subsequent field trials, crushed corn cobs were used largely because they showed more all-around promise when cost and ease of mixing and spreading were considered. The corncobs were put through a burr mill and winnowed, leaving the pieces about one-quarter to one-half an inch in diameter to be used in the bait. Sugar-beet pulp, peat moss, sawdust and some other materials were also used as carriers. Fermented mixtures of various kinds and sugar were the main attractants used although many others were tried. Several

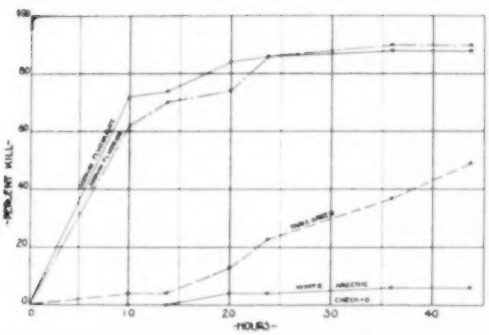

FIG. 3.—Comparative kill of the alfalfa snout beetle with different poisons in raisin-shorts bait at 70 degrees.

materials such as soybean flour, skimmilk powder, glue, glycerine, gum arabic, two invert sugar syrups (*Kristokleer D3* and *Syrline*), various oils, and other materials were used as stickers and conditioners. In addition to tests of these mixed baits work was continued using fruit baits. Of these fruit baits some combinations using grape pomace, showed promise and were cheaper than the raisin bait. The relative efficiency of various insecticides as well as the problem of bait storage was studied.

COMPARISON OF INSECTICIDES.—An effort was made to get some measure of the effectiveness of different insecticides in

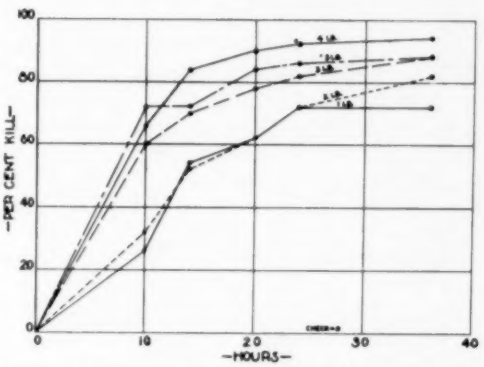

FIG. 4.—Comparative kill of the alfalfa snout beetle with varying dosages of sodium fluosilicate at 70 degrees.

the standard raisin bait. Figure 3 presents a comparison of paris green, white arsenic, sodium fluoride, and sodium fluosilicate in the standard raisin bait with fifty beetles in cage experiments at 70 degrees in 1937. Under the conditions of these experiments the arsenicals were much inferior to the fluorine poisons. Possibly under field conditions the baits with the fluorine poisons might be even more efficient than the paris green or white arsenic baits because of the rapidity of kill obtained while the baits are fresh.

A comparison of varying dosages of sodium fluosilicate in one hundred pounds of standard raisin bait with fifty beetles in cage experiments at 70 degrees is given in figure 4. Dosages of 3, 4, and 5 pounds of sodium fluosilicate are significantly better than dosages of 1 or 2 pounds. Except as indicated in figure 3, all baits that were tested contained sodium fluosilicate as the insecticide.

EFFECT OF MOLDS ON BAIT.—Sometimes standard raisin bait is kept in common storage during a period warm weather and mold growth caused the bait to heat and become covered with mycelial growth. It was a matter of interest to know the efficiency of such bait as compared with fresh bait for the control of *B. ligustici*. The comparison included in figure 5 was

made on one hundred and fifty beetles in cages at 70 degrees. The moldy bait was three weeks old when the tests were begun. The fresh bait is significantly better

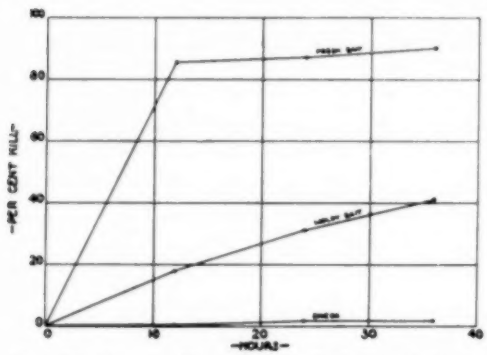

FIG. 5.—Comparative kill of alfalfa snout beetle with moldy raisin-shorts bait at 70 degrees.

than the moldy bait, although moldy bait is significantly better than the check.

Because of the unattractiveness of moldy bait the possibility of using a preservative to keep the bait from spoiling was investigated in 1938. Sodium benzoate at the rate of two-tenths per cent on dry weight basis of the bait materials was satisfactory for this purpose. Standard raisin bait containing sodium benzoate was given extensive trials to see if it was as effective as the standard raisin

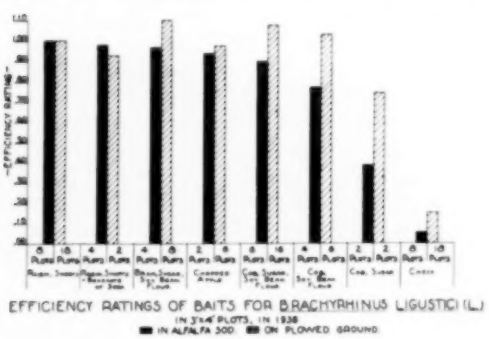
EFFICIENCY RATINGS
EFFICIENCY RATINGS OF BAITS FOR BRACHYRHINUS LIGUSTICI (L.)
IN 3'X4' PLOTS, IN 1938
IN ALFALFA 300
ON PLOWED GROUND

FIG. 6.—Efficiency ratings of baits for the alfalfa snout beetle.

bait, or if the sodium benzoate repelled the beetles.

BAIT TESTS IN 1938.—Figure 6 presents the efficiency ratings of some of the substitute baits in comparison with standard raisin bait in 3 by 4 foot plots in alfalfa and on plowed ground. Standard raisin bait with sodium benzoate added as a preservative was equal to the standard raisin bait with no preservative added. Both of these baits were freshly ground at the time they were spread. A bait prepared with 5 pounds of sodium fluosilicate and 100 pounds of chopped apple also compared favorably with the standard raisin bait.

Bran-sugar-soybean flour bait and cob-sugar-soybean flour bait were slightly less efficient than the standard raisin bait when used in alfalfa but were more efficient on plowed ground. The raisin bait appeared to be slightly more attractive to the beetles when growing alfalfa offered competition. Since the bran and cob baits were mixed and not ground, there was a higher concentration of poison on the outside of the bait particle. This accounts for the greater kill given by these baits on plowed ground.

Crushed corn cob-soybean flour bait and crushed corn cob-sugar bait were less efficient than the corn cob bait containing both of these ingredients. These bran and corn cob baits were mixed according to the following formula: crushed corn cobs or bran, 100 pounds, granulated sugar, 40 pounds, soybean flour, 15 pounds, sodium fluosilicate, 8 pounds and water to moisten the bran or cobs.

Table 1.—Summary of counts in quarter-acre bait plots in alfalfa in 1938.

	Days After Treatment				
	1–5	6–10	11–15	16–20	21–27
Raisin shorts					
No. beetles	78	78	126		
Per cent kill	37	74	87		
Raisin shorts plus sodium benzoate					
No. beetles	101	76	50	50	25
Per cent kill	43	84	100	100	100
Raisin soybean flour					
No. beetles	104	80	50	51	
Per cent kill	73	92	94	98	
Apple					
No. beetles	91	79	50	50	
Per cent kill	53	89	98	100	
Apple					
No. beetles	110	75	50	51	26
Per cent kill	63	85	98	98	100
Cob, brew, soybean flour *Kristokleer D3*					
No. beetles	110	75	50	54	35
Per cent kill	47	88	100	100	100
Cob, brew, soybean flour					
No. beetles	20	80	50	50	25
Per cent kill	55	29	46	56	52
Cob, sugar, soybean flour					
No. beetles	101	75	50	51	26
Per cent kill	69	91	98	100	100

Because of the migrating habits of the beetles and the unevenness of the population, large scale field plots have been difficult to manage. In addition, the control campaign conducted by the New York Department of Agriculture and Markets has reduced the population of beetles until only a few fields have sufficiently heavy populations to give significant counts. The results obtained from the use of seven substitute baits compared with the standard raisin bait in one-quarter acre field plots in alfalfa are presented in table 1. The standard raisin bait with sodium benzoate chopped apple bait, cob-sugar-soybean flour bait, and cob-brew*-soybean flour-*Kristokleer D3* bait were all equal in efficiency to the standard raisin bait. Cob-brew*-soybean flour bait with no *Kristokleer* was considerably less efficient. This difference is exaggerated by the fact that in the plot receiving the cob-brew-soybean flour bait, there was a heavy growth of alfalfa and a sparse population of beetles.

The cob, soybean flour, brew bait was prepared by substituting eight gallons of brew for the forty pounds of sugar and water necessary to moisten the cobs. The cob, soybean flour, brew, *Kristokleer D3* bait differed from the foregoing mixture in that six gallons of brew and two gallons of *Kristokleer D3* were used in the formula instead of eight gallons of brew. The raisin-soybean flour bait consisted of twenty pounds of raisins, eighty pounds of soybean flour and five pounds of sodium fluosilicate. The soaked raisins were mixed with the dry ingredients and ground with a food chopper.

SUMMARY.—For the past four years, experiments with poison baits have been carried on in an attempt to devise a cheap and effective control for the alfalfa snout beetle, *Brachyrhinus ligustici* (L.). Four years' data have shown that raisin-shorts-sodium fluosilicate bait is very effective and possesses the desirable physical qualities necessary for a long life under field conditions. In 1938 several promising substitute baits were developed. The best of these is a mixture of crushed corn cobs, soybean flour, granulated sugar, and sodium fluosilicate. Paris green and white arsenic are much less effective as insecticides than sodium fluosilicate and sodium fluoride. Standard raisin bait that has been stored long enough to become moldy is unattractive. Sodium benzoate is an effective preservative to prevent molding of raisin bait and is not repellent.—8-7-39.

* The term brew is used to designate a three day old fermented mixture of sugar and water using 1 pound of sugar to 1 gallon of water. Yeast was added to hasten fermentation.

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Entomological Considerations in Utilization of Insect-Killed Ponderosa Pine

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The heavy depletion of ponderosa pine, *Pinus ponderosa* Laws., and other western pines caused by the attacks of cambium-mining insects presents one of the most important problems affecting the timber supply of the western states. This depletion, chiefly in overmature stands, has steadily accumulated and has become increasingly important during the past two decades. Timber owners interested in applying control measures have been faced with the high costs and, under some conditions, doubtful benefits often derived. Craighead, *et al.* (1931) have shown these limitations to be particularly serious in the commercial stands, which comprise most of the pine forests. Control work carried on concurrently with the salvage of insect-killed timber was suggested as a hopeful solution. The costs on three projects of this nature in northern California and in southern Oregon in 1928 and 1929 were shown by Keen (1931) to have been considerably less than the

value of the insect-killed trees when salvaged and taken to the mill for utilization.

Aside from any control possibilities, the utilization or salvaging of insect-killed pine has often been recognized as a means of converting at least a portion of losses into usable products. Despite this oft-proposed measure, the proportion of "bug" timber actually utilized has been negligible. It is believed that the chief factors responsible for the lack of salvage have been (1) the large areas involved; (2) the distribution of the losses in the stand, usually scattered and often inaccessible; (3) the inability of conventional logging methods and equipment to cope with this type of utilization; and (4) severe degrade given beetle-killed timber because of blue staining.

Little opportunity has been available to study the entomological aspects of the salvage problem. In 1935, however, the Bureau of Entomology and Plant Quarantine, in cooperation with the Forest Service, studied two extensive salvage operations carried on by two large lumber companies in northern California. Although certain phases of these studies were designed chiefly for the interest of foresters and lumbermen, forest entomologists were able to attain two main objectives, (1) the relationship of the infestation in individual trees to the percentage of cull or degrade from blue stain and (2) the control effect of salvage operations. Discussion in this paper is limited to these phases and does not cover costs, derivative products, and the detailed logging methods studied by other agencies.

Both salvage studies were conducted in northeastern California during the spring and summer of 1935. One operation was carried on in eastern Shasta County and covered an area of 8,000 acres of pure ponderosa pine, mostly in private ownership. Approximately 2,300,000 board feet of insect-killed timber was salvaged. The other area was located in Lassen County. Here on an area of 6,000 acres, over $2\frac{1}{2}$ million board feet of pine were salvaged. Of this total, four-fifths was ponderosa pine and the remainder Jeffrey pine, *Pinus jeffreyi*, "Oreg. Comm."

METHODS.—On each of the two salvage areas all currently infested trees were located and marked for cutting. After the trees were felled, a complete analysis was made of each bole on one 320-acre plot in each of the two salvage areas to determine the location and amount of bark surface occupied by the various stages of the infesting insect species.

The salvaged logs were taken to the sawmills for prompt utilization. Slabs containing heavily infested bark were burned to prevent the emergence and spread of the beetles.

A special mill-scale study was conducted on the Lassen project, whereby numbered logs from the woods were followed through the entire milling process to the finished product in order to obtain an accurate measure of the degree of utilization of the salvaged trees.

The sample plots mentioned above were also used to study any possible control effect brought about by the removal of infested trees. Beetle-caused losses prior to and following salvage were measured on these plots.

RESULTS.—In normal logging operations there is a relatively short time elapsing between cutting and utilization. Under these conditions lumbermen are rarely confronted with blue stain development serious enough to impair utilization values. Rapid development of blue stain, however, becomes a serious problem when salvaging insect-killed pines. The blue stain fungus *Ceratostomella pini* Münch, has been shown by Rumbold (1931) to be closely associated with the western pine beetle, *Dendroctonus brevicomis* Lec. The heavy blue stain which developed in the salvaged material soon after attack by *Dendroctonus* and *Ips* beetles resulted from the spread of the staining organism from the newly mined insect galleries. Its appearance and rate of spread seemed to be correlated with insect species and brood development.

An analysis by J. R. Berry* showed the amount of degrade resulting from blue stain. In general the average percentage of degrade due to blue stain was found to vary according to the development of the insect broods, amounting to about 12 per cent in the trees salvaged 1 year after attack. The former trees contained bark-beetle broods up to the advanced larval stages and the latter trees were abandoned by all primary insects.

Similar blue stain degrade was noted for similar brood stages of most of the

* In U. S. Forest Service memorandum to Fruit Growers Supply Company, dated July 24, 1935.

barkbeetle species present. Staining was much more rapid than average in trees attacked by *Ips emarginatus* Lec. and much slower in those attacked by the California flatheaded borer, *Melanophila californica* Van Dyke. The percentage of blue stain deductions is expressed below in tabular form indicating species and brood responsible for the loss.

These data indicate the need for rapid utilization following attacks by barkbeetles in those situations where blue stain is culled in the finished product. Where blue stain is not a factor of cull, utilization is then dependent upon the normal deterioration caused by weathering, wood-rotting and other staining fungi, and wood-boring insects. Deterioration has been shown by Boyce (1923) and Patterson (1930) to be insignificant in the trees during the first year following death, but to increase rapidly thereafter.

The salvage operations were similar to the control measures used in combating barkbeetle outbreaks in that an attempt was made to remove or destroy as much of the current beetle population as possible. Of the 145,000 square feet of bark surface included in the trees marked for salvage, 15 per cent was uninfested, 68 per cent infested, and 17 per cent abandoned by emerging broods. Salvaged material removed from the woods included approximately 94 per cent of the uninfested and 90 per cent of the infested bark, the unsalvaged portions being chiefly in unmerchantable tops and broken chunks.

Table 1.—Blue stain deductions as related to species of insect and stage of development.

Per Cent Blue Stain Deduction	Insect Species	Brood Stage
0	*Melanophila californica*	Eggs and small larvae
10	*Dendroctonus brevicomis* *Dendroctonus jeffreyi* *Dendroctonus monticolae* *Ips oregoni*	Parent adults, eggs, and small larvae
	Melanophila californica	Large larvae
25	*Dendroctonus brevicomis* *Dendroctonus jeffreyi* *Dendroctonus monticolae* *Ips oregoni*	Small and large larvae
	Ips emarginatus	Parent adults, eggs, and small larvae
	Melanophila californica	Prepupal larvae and pupae
50	*Dendroctonus brevicomis* *Dendroctonus jeffreyi* *Dendroctonus monticolae* *Ips oregoni*	Large larvae and beyond
	Ips emarginatus	Small and large larvae and beyond
	Melanophila californica	Pupae and beyond

The removal of a large proportion of the beetle populations and the arrested development and heavy mortality from solar heat of the broods remaining in the unsalvaged tops and chunks is believed to have been a significant factor in the reduction in insect losses following salvage. The 1935 infestation was used as a basis for this conclusion because it was directly affected by the salvage operations. Most of the overwintering generations in 1934 and early summer generations in 1935 were removed from the woods and the subsequent 1935 summer and winter attacks were greatly reduced. A comparison between the 1934 and 1935 losses occurring on the salvage areas and on natural areas was made on both the Lassen and Shasta salvage projects by means of several 320-acre sample plots (Table 2). A further comparison was possible on the Lassen project between the salvage plot and one included in a nearby barkbeetle control project directed against the 1934 overwintering population. On the latter project the infested trees were felled, peeled, and the bark burned to destroy the broods.

Table 2.—Barkbeetle infestation in 1935 as compared with that in 1934 on salvage, direct control, and check plots.

Project Area	Plot No.	Treatment	1935 Infestation In Per Cent of 1934 Infestation
Shasta	MC-10	Salvage	60.3
	RS-6	Check	100.1
Lassen	L-15	Salvage	61.1
	L-3	Direct Control	60.7
	L-1, 5, 7	Check	108.7

The advantages gained were apparently only transitory, as the losses the second year following salvage appeared to approach the level of the untreated areas. It is believed that a more favorable control effect would have resulted had the salvage program been confined to the months when control measures are more effective.

Results of this study have shown that utilization of pine timber killed by barkbeetles is a possibility which is apparently

limited only by economic considerations. These would be offset to a considerable extent if a positive control effect could be assured. A salvage plan which would include, along with insect-killed timber, such green trees as are likely to be attacked in the near future appears to coincide with a growing trend in timber management toward lighter initial or sanitation cuts.

SUMMARY.—Experimental logging operations were conducted by two lumber companies in northern California during 1935 to salvage timber values left in trees killed by barkbeetles. Nearly 5,000,000 board feet of dead and dying yellow pines were removed from the woods and utilized in nearby sawmills. Entomologists cooperating in the study were interested in determining (1) the relationship between barkbeetle development and blue staining and (2) the control effect of the salvage operations.

Infestation patterns made from bole examinations of felled infested trees were used in demonstrating a significant correlation between the blue staining and the insect species present and between the staining and brood development. Degrade from blue staining amounted to as high as 50 per cent in trees containing advanced broods of *Dendroctonus*, *Ips*, and *Melanophila*.

A decline of 40 per cent in infestation the year following salvage was noted. Infestations in check areas for the same period remained unchanged or slightly increased. The reduction in loss obtained on the salvage area was approximately the same as that following a direct control project accomplished under very similar conditions on a nearby area.—4-15-40.

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Standardization and Uniformity in Plant Pest Control

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The control of plant pests by regulatory procedure has been under way in this country now for many years, certainly fifty. State inspection of nurseries began as early as 1889. In 1912, the Federal Plant Quarantine Act stimulated nation-wide interest in pest restrictive measures; six years later Federal Plant Quarantine No. 37 gave further impetus to the utilization of plant quarantines by state as well as national agencies. For some thirty years this Association has been officially interested in inspection, certification, and quarantine procedure as a means of preventing and checking the introduction and dissemination of insect pests and plant diseases. In 1902, it established the American Association of Official Horticultural Inspectors. In 1913, the American Association of Economic Entomologists appointed a committee on Uniform Crop Pest Control Legislation.

Thus began an organized effort on the part of this group to bring about more effective inspection and greater uniformity in certification as a means of pest control by authority of law.

As a result of the widespread interest which followed, there were later set up four regional plant boards, headed by a National Plant Board. This organization of plant boards started in 1924. So much to refresh our memories on the sequence of events.

Now, after all these years of operation, what progress has been made with plant pest control in the United States? Are we satisfied with the present situation? If not, wherein lie the difficulties?

The title chosen for this paper, Stand-

ardization and Uniformity in Plant Pest Control suggests a solution for some of our present difficulties. I would point out therefore, in answer to the questions just asked and at the risk of much repetition, the following suggestions for your consideration.

Discussion of standardization and uniformity in the inspection of nurseries in drawing up inspection certificates; in defining nursery stock, pests, and diseases; in the texts of quarantines, and finally in enforcement matters, has repeatedly been presented before this quarantine section. In spite of such repeated emphasis on the subject, although there has been much progress, it seems to me to have been altogether too slow in the past and continues to lack the necessary force to land where it should have landed a decade ago. As Mr. Gaddis so ably and clearly pointed out to quarantine officials in Chicago three years ago, the plant pest control structure is in a tangled, chaotic condition, due largely to the lack of uniformity and standardization of the foundation timbers. Dr. Chambers last year in Richmond, in his address before this section, emphasized the need of uniformity in procedure and pointed out that there was evidence of a lack of confidence in state certification. I fully agree with him as to this lack of confidence and wish to emphasize it.

Three speakers on our program last year turned to federal or national leadership in some form as the solution of present difficulties. A single Federal-State certificate should be the only requirement needed to carry nursery stock inter-state, in my opinion. This means that the Federal Government must appear in the picture.

All of us seem to agree that there are too many forms of certificates and too many variations in quarantines of the several states on the same subject.

Certainly the fact that there are 207 state quarantines to cover 52 pests, as reported by Gaddis in 1936, emphasizes this point.

I feel that if state crop pest officials become seriously convinced that there is a real need for a more efficient inspection, certification, and quarantine service, rapid progress will be made. Such progress, however, must start at home; that is, within the state areas. But state officials must at the same time realize that the difficulty also involves fields beyond state lines. If and when this happens, the first large obstacle will be overcome. My observation is that this inspection and quarantine job is prone to be too carelessly done at home. Knowing that, we hesitate to accept the other fellow's certificate on face value; we prefer to check on it at destination points, especially when dangerous pests are involved. That means our state inspection procedure should be more thorough and that directions in some detail for inspection and treatment for specific pests should be announced by each state. As an example: "Requirements and Directions for Plant Pest Control," which was adopted by the Central Plant Board three years ago is a step in the right direction. It should be announced and published by the state authority that nursery inspection should cover common pests of general distribution and that certified stock must not be infested with such pests. There is such a thing, of course, as going too far in the case of pests that are present everywhere and cause little or no damage. But the customer should be protected and be assured that the certificate actually gives the protection that it guarantees.

In considering quarantines, the state unit should realize that only major pests, those not generally established, should be subjects for quarantine procedure. Fortunately, in recent years the trend appears to be away from quarantine action; but since quarantines usually extend beyond state lines, uniformity is fully as essential as in the case of certificates for common pests.

This shows the necessity of a broader, nation-wide viewpoint. We should give full and generous consideration to other units which become involved. The question of trade barriers as a nuisance is receiving much attention just now on the part of government authorities and representatives of industry. Industry is "fed up" on restrictions which interfere with inter-state movement of many commodities. Plant quarantines are named as one of these barriers.

It behooves us, therefore, to consider the problems of those who are required to comply with plant quarantine regulations. If we are successfully and effectively to prevent the introduction and dissemina-

tion of plant pests in this country, my experience teaches that we must have the support of public carrier units and the affected progressive trade units. In fact, all the following units must endorse plant pest control activities if successful enforcement is to be obtained.

(1) Common Carriers
(2) Nursery Associations
(3) Individual Nurserymen
(4) Private Individuals
(5) Post Office Departments
(6) Federal Units
(7) State Units

These units, being concerned with inter-state and intra-state movement of regulated plants and plant products, undoubtedly are considerably hampered on account of quarantine and inspection regulations which differ widely in the several states. A real grievance, therefore, exists; and I believe the way out is to continue to meet with these trade units or agencies and endeavor to modify, simplify and perfect plant pest procedure as much as possible. Quarantines and certification requirements must be changed or eliminated from time to time as experience dictates.

I am informed that the Executive Committee of the American Association of Nurserymen is to meet with members of the National Plant Board in Cleveland on January 15, 1940 to discuss the numerous plant pest regulations which interfere with the inter-state movement of nursery stock. It is to be hoped that from this meeting may come progress, and perchance a solution of the principal difficulties.

All units must, of course, cooperate, and there must above all be leadership. We must utilize as such leaders the regional and national plant boards and keep them working. Then, finally, if the states through these boards, cannot agree on a standard certificate, we must turn to federal leadership in some form. I feel that the quarantine situation can and will be cleared up through Federal-State relations, but we may have to come to a federal certificate for inter-state movement. This may originate under authority of a federal act, licensing state inspectors to issue Federal-State tags as is now the case with The Grain Standards Act, The Marketing Act, and others. This licensing of state crop pest inspectors by the Secretary of Agriculture appears to me to be thoroughly practicable. I should like to see it seriously considered.

The Federal Seed Act passed by the last Congress is a very recent example of the trend in simplifying certification of products moving in inter-state commerce. This act requires a label of quality as a prerequisite for inter-state movement. The merchant in this case supplies the certificate on his own examination of the product. Federal or state certification in advance is not required. Hence, there is an important difference between the procedure under the Seed Act and that which would be necessary under a Federal Plant Pest Act. However, the principles of uniformity and standardization are effectively assured by this act. Of course intra-state movement is a local matter and must continue so. Given federal supervision and authority *in cooperation with the states*, it is my judgment that the standard of nursery inspection procedure would be more nearly satisfactory to all agencies concerned than at present; and I think this group and the state groups should give it serious consideration.

In conclusion, I should like to emphasize again that we must work with related and interested units, commercial as well as technical, if plant pest control by means of regulatory measures is to be successful and actively supported and endorsed by our leading authorities in science and industry, and by the public at large.

We must work together, plant pathologists, entomologists, state and Federal administrative officers and representatives of the nursery trade, if pest control regulations are to be enforced. Without the support of these groups generally, it will continue to be difficult to cope effectively with these plant pest problems.

It is not enough to stop at principles; the details of procedure must be established, published, and generally distributed to all groups and individuals affected.

Doubt on the part of some entomologists, plant pathologists, and administrative officers as to the real value of plant quarantine and control continues to exist. We must listen to their side of the story; and if our platform is weak, revamp it and, if necessary, eliminate the weak parts.

It is encouraging that again a joint meeting with the American Phytopatho-

logical Society could be arranged by this section. Plant diseases and plant quarantines must be considered by entomologists and plant pathologists together if intelligent procedure is to be developed. More frequent contacts between these two groups of workers should be encouraged.

Our secretary has chosen for discussion this afternoon the subject "Federal-State Relations," and I am sure we shall profit much by an extended elaboration of these relations by representatives of the Federal Bureau, on the one hand, and by state representatives on the other.—3-11-40.

Federal-State Relations

WILMON NEWELL, *Plant Commissioner, Florida State Plant Board*

This paper deals chiefly with the relations between the states and the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, with particular reference to eradication or large-scale control projects. References are also made to the need for improvement in the manner of enforcing our plant quarantines.

It is a known fact that practically all of our destructive plant pests are introduced species. Some of them, like the Mediterranean fruit fly, reached our shores with such an internationally known reputation for destructiveness that no difficulty was experienced in securing the necessary financial and legal aid for the prosecution of a vigorous eradication campaign. The destructive nature of others, like citrus canker and Japanese beetle, was unknown when they arrived in this country. It was not until 1915, some five years after canker was introduced into the United States that an organized eradication program was undertaken. By that time the disease had spread into all of the citrus-producing areas of the South, with devastating results. Had we known in 1916 of the destructive habits of the Japanese beetle, an aroused public would have insisted that an effort to eradicate be made immediately.

It is not the newly introduced plant pest of known destructive habits that we should fear. It is the unheralded invader to which scant attention is paid until it has become established over a large area and is causing great losses to growers. By this time, eradication is impractical, or too costly a task to undertake. Periodical surveys by a competent committee should be made of areas affected from the time the insect is first found until sufficient time has elapsed to make possible its rating as a plant pest of economic importance.

If considered to be, potentially, a pest of considerable economic importance, consideration should be given to the question of eradication. If eradication is desirable, and is practical, the next question is "How will the project be financed?"

Common sense indicates that eradication should be a three-cornered undertaking. The growers should carry their share in order to protect their livelihood; the state, in order to save an established and revenue-producing industry; and the Federal Government in order to protect this same industry over a large section of the country. In the days of not so long ago, this was the case. Growers confronted with destruction of crops as a result of attacks by a newly introduced plant pest, did not wait for outside aid, but themselves made determined efforts to combat the menace. In the early days of the citrus canker invasion in Florida, growers volunteered their services as inspectors without pay; their womenfolk frequently carried on the field work, thereby releasing the men for control activities. Bearing and non-bearing citrus trees were destroyed by fire without any question of compensation. In addition, growers and allied interests contributed some $85,000 in cash to fight off destruction of their groves until state and federal aid could be secured.

Today we face a changed condition. Aid in controlling the commonest plant pest has been forthcoming through the WPA and in eradication or large-scale control projects, the control organization is expected to supply and make application of materials used in control activities.

If plants or plant products are destroyed in an attempt to save the growers' means of livelihood, demand is made for compensation. With this attitude prevalent among the majority of farmers and horticulturists, no state is financially able to underwrite the costs of a major plant pest eradication project.

In using the term "major plant pest," reference is made to introduced pests, such as citrus canker, Mediterranean fruitfly, Japanese beetle, and pink bollworm, capable of causing tremendous economic losses over an entire state, or states, as contrasted to pests whose potential destructiveness is limited by climatic conditions and food habits, and whose control by the grower is practical and not too costly. With respect to the latter, we believe that the state should carry the greater part of eradication costs.

This point may be illustrated by our experiences in Florida, in the case of three successful plant pest eradication projects. Citrus canker and Mediterranean fruitfly are major plant pests capable of causing tremendous losses throughout the South and West. It is doubtful if either can be controlled on a commercial scale. On the other hand, the menace presented by spiny citrus whitefly, or blackfly (*Aleurocanthus woglumi* Ashby), a pest capable of destroying the citrus industry of south Florida, if uncontrolled, is probably limited by climatic conditions to a comparatively small area, and can be overcome by the use of oil sprays now being used by citrus growers. Blackfly, from a national standpoint, may be considered as a minor plant pest. The eradication campaigns waged against these three pests were cooperative, and the proportion of costs assumed by the Florida Plant Board and the United States Department of Agriculture, was as follows:

Citrus Canker, State, 54 per cent; Federal, 46 per cent; Mediterranean fruitfly, State, 5 per cent; Federal 95 per cent; Blackfly, State, 82 per cent; Federal, 18 per cent.

When an eradication campaign is carried on in two or more states it is, in most cases, desirable that all project activities be headed by a federal employee. This is so that all activities may be coordinated and conducted most effectively. But the federal leader should always keep in close touch with state officials. He should always remember that the scope of activity of a state quarantine officer is limited by his state legislation. What is permissible in one state may be illegal in another. For this reason, it is essential that the federal project leader consult fully with state officials before any change is contemplated in the eradication program.

I believe that an honest effort to maintain close contacts with state officials is being made by Bureau officials. However, the time of the project leader is taken up by conferences with grower committees, who finish their business in a few minutes, and then spend hours visiting. He has to listen to complaints of growers and shippers, and to an endless number of applicants for work. He is lucky if he finds time for an uninterrupted meal. Perhaps, therefore, he should not be too severely censured if he occasionally neglects to supply state officials with essential data.

With the view of preventing the possibility of misunderstanding and friction on the part of cooperating agencies, some consideration should be given to the idea of having assigned to each eradication or large-scale control project a coordinator, whose chief duties would be to maintain close contact with cooperating state officials and the project leader, both with respect to field and research. Thus all would be fully informed at all times as to what each was doing.

Looking back over a period of years, I can recall actions on the part of federal officials in charge of cooperative eradication projects that were not conducive to a spirit of cooperation. These include:

1. Enforcement of intra-state quarantines discontinued without advance notice.
2. Bureau of officials made survey trips to the state during an eradication campaign without informing the cooperating officials of their intentions.
3. Appointments of men to fill responsible positions in the eradication project without consultation with the state officials. Continuance of appointees in responsible positions when it was evident that they were unfit to carry on duties assigned to them. Removal of men well qualified for the tasks to which they were assigned without first consulting the state cooperating agency.

4. Creation of grave risks to life and property by unauthorized changes in the formulae of mixtures used in a control project without first consulting cooperating organizations.

While capable federal supervision is conducive to the successful conclusion of a control or eradication project, progress is hindered unless adequate state legislation is provided. State quarantine officials should consider carefully their laws dealing with the control of plant pests, and, if found inadequate, make every effort to have suitable legislation enacted.

Fracker has warned state officials that it is essential that all the needed powers of access, inspection, treatment, destruction, and quarantine be specifically authorized in their pest control laws. A mere authorization to the administrative body "to take such measures as may in its judgment be necessary" has been held by the courts to be insufficient to justify and legalize regulatory orders. Where the needed specific authority is granted, however, the statutes themselves, and orders issued under them, have been upheld by Supreme Court decisions as not contravening either the "due process" clause of the constitution, or that clause which forbids the taking of private property for public use without compensation.

Successful eradication or control is based in large measure on information that can be secured only through research and, unless the project is provided with a well-staffed and aggressive research section willing to pass information on to the control forces as rapidly as developed, the success of the project may be jeopardized. Frequently, the research man is loath to risk his reputation by advancing information without first checking and double-checking his results. He may be right, but the tempo of an eradication campaign is usually so terrifically fast that a delay of even a few days in striking at a vulnerable point of a pest may be disastrous. If the man in charge of research is not practical enough to realize this, and is not willing to take a chance, the Bureau should assign to each project a man capable of analyzing the work of the research section and passing essential information on to the eradication forces.

It would appear that the old cry of "Millions for defense, but not one cent for tribute" has been taken over and revised to read "Millions for control, but only a few dollars for research." Money wasted on some ill-advised action of an eradication force might pay the salaries and expenses of several research workers for a year or more. Yet, every eradication project is handicapped by the paucity of funds allotted, and personnel assigned, to research activities. The blame for the lack of appropriations for suitable research rests, to some extent, upon the state quarantine officials. If the Bureau Chief's recommendations for funds for research are turned down or curtailed by the Director of the Budget, his hands are tied. He cannot appeal to outsiders for aid. But outsiders, in this case state quarantine officials or members of the Regional and National Plant Boards, whose interest it is to follow closely the progress of the Bureau's budget recommendations, can, and should, through their Congressional delegations, reach the Director of the Budget and impress upon him the urgent need for funds for research work.

Whenever possible, state and federal research investigations of newly introduced plant pests should be coordinated, unless there is some unusual factor peculiar to a given state which justifies local research activities. This is particularly true with introduced pests not widely distributed, and where the investigations entail the use of the pest or organism in a viable state; such activities should be conducted, as a rule, only in areas where the pest is established and, of course, under adequate safeguards. Such coordination would greatly expand and speed up the research program, and would tend to eliminate waste of funds and duplication of effort. An effort towards coordination has been undertaken in the case of the white-fringed beetle investigations. The money available to the Bureau for this work was inadequate and has been supplemented by state funds from Florida, Alabama, Mississippi, and Louisiana. In so far as Florida is concerned, this arrangement has been most satisfactory.

Prevention of the entry of plant pests is by far preferable to the need for eradication or control after entry and establishment. Plant pests continue to slip into the country in spite of numerous foreign plant quarantines promulgated with the view of preventing their entry. Are such occurrences due to loopholes in the quarantines

themselves, or are they due to the manner in which the quarantines are enforced? There are without doubt many faults to be found in our restrictive quarantines. Doctor Strong, in his paper "What Is Wrong with Quarantine No. 37?" has called to our attention many defects in this important quarantine. It is to be hoped that this, as well as other restrictive quarantines, will be strengthened and become what they were intended to be—instruments providing means for preventing entry of foreign plant pests. At the same time, strict enforcement of an inadequate quarantine is better than lax enforcement of a perfect one.

Towards the end of his paper Doctor Strong asks another question, namely, "What should be done to Quarantine 37 to make it a sound, workable instrument designed, consistent with the aim of the Plant Quarantine Act, to prevent entry of plant pests and to facilitate the entry of plants?"

In this question is to be found the chief fault of present-day quarantine enforcement. So much thought has been given to means of facilitating entry of plants and plant products that prevention of entry of plant pests has at times seemed to be secondary.

There are two distinct classes of materials for which importing permits are required. The first includes such things as bulbs, tree seeds, etc., which are given a preliminary inspection at port of entry to determine whether there are present insects or diseases which might escape in transit.

The purpose of Quarantine No. 37 was to reduce the risk of introducing pests. If prevention of entry of insects and diseases is the intent of the quarantine and the task of quarantine officials, the efforts of the Bureau's inspectors should be devoted to the task of seeing that importations of this class of material are pest-free. Instead of concentrating on this important task, it appears that in large measure their efforts are directed towards ascertaining that the material has been properly certified by a foreign inspector and that prohibited material has not been included. Yet, in the case of shipments entered under regular permit, which constitute the bulk of the importations, only a few of the crates in each shipment are opened for examination at the port of entry. The entire shipment is then allowed to proceed to destination, on the assumption that the state inspectors will make more complete inspections and apply treatment if necessary. It must be admitted that in spite of foreign inspection and certification, plant pests are often found on certified plants.

The second class, consisting primarily of plants arriving under special permit, is a small fraction of the total importations, and is sent to Washington, San Francisco, or Seattle for examination, where facilities are provided for treatment by heat or cold, or by vacuum fumigation.

If plant pests are to be excluded, both of these classes of material should be inspected and, if necessary, treated. As suggested by Doctor Strong, the quantity of plant material imported should be limited to the Bureau's physical ability to inspect properly and safeguard adequately all plants arriving from foreign ports. Why are such limitations not imposed? If the intent of the quarantine and of Bureau officials is to prevent entry of foreign plant pests, inspection and, if necessary, treatment should be made one of the conditions of entry. And by inspection is meant a close examination of all of the plants in each crate, and not a hasty glance at only one or two crates.

It must be admitted, of course, that the chief limitation as to inspection and treatment is one of resources. No one who has given careful thought to this problem and is qualified to express an opinion would say that the present procedure should not be improved. Therein lies the responsibility of agriculturists and state pest control agencies, the primary responsiblity of course resting on the Bureau to ask for sufficient appropriations to accomplish the objectives. Agriculturists and quarantine officials should then analyze that estimate and, if finding it inadequate, acquaint their Congressmen with the situation.

Now, as to the protection afforded against entry of plant pests on shipments of fruits and vegetables. Provision is made in Quarantine 56 for safeguarding the entry of such commodities; the quarantine goes so far as to state that the inspector may require inspection or disinfection, or both as conditions of entry. Yet treatment is not specified unless infestation is detected in the material, and since the

Bureau is satisfied with sample inspection at ports of entry, the only recourse is to require treatment to supplement the sample inspection.

Importers often object to treatment of their shipments. They claim that the produce is perishable and, as such, is likely to be damaged either by the delay incidental to treatment or by the treatment itself. Perishable also, by reason of attacks by plant pests, are our vast horticultural and agricultural interests. They should not be placed in jeopardy because of the desire of a few importers to enrich themselves.

Now as to the status of domestic quarantines. Motor truck transportation has wiped out the effectiveness of the natural barriers which, in the past, helped check the spread of plant pests. It has increased the rate of spread from one section of the country to another, and from point to point in the state. In the past, when the bulk of the movement of plants and plant products was by freight, express, and vessel, compliance with inspection and certification requirements was obtained in large measure by supervision of movement and penalties imposed on transportation officials when violations were noted. Today, a large portion of the plants and plant products of a type formerly moved by rail and water is carried by motor truck.

How many state quarantine officials are making a determined effort to supervise motor truck transportation? In an effort to explain failure to attempt to regulate this movement, the argument is advanced that nothing can be accomplished without the establishment of quarantine stations on every road entering the state. Establishment of such stations would probably lead to port of entry legislation—and the establishment of additional trade barriers, of which there are entirely too many.

We are convinced that unless some constructive action with respect to transportation of plants and plant products by motor truck is taken by state quarantine officials themselves, such action will be forced upon them by rail and water transportation interests, which are becoming irked at the apparent partiality which allows motor truck operators to do what they themselves are prevented from doing. The support of transportation officials in preventing movement of plant pests, in securing suitable appropriations, and even plant pest legislation, has been of tremendous value in the past. Only by fair play can we expect to retain this support.

It is doubtful if state quarantine officials as a whole can be criticized for the trade barriers that have been enacted during the past several years. Such legislation is probably the offspring of short-sighted politicians eager to secure additional, but temporary, revenue, aided and abetted by special interests foolish enough to think they could eliminate competition. It would appear that the menace presented by the enactment and enforcement of legislation restricting free trade among states is causing some concern among public officials. Only last spring there were prepared three comprehensive reports on interstate trade barriers. Copies of these reports should be in the files of every quarantine official. They can be used to good effect in forestalling enactment of similar legislation. It is urged that these reports be used as references in every college where courses in plant quarantine are given.

There are indications in these reports that there has been an awakening on the part of legislative bodies as to the menace presented by trade barrier legislation. This is evidenced by reports of the repeal by some states of such legislation, and the refusal of state legislatures to enact additional laws. The Solicitor General of the United States, Robert H. Jackson, has warned the public that his office will continue to support private litigants and to take direct action in the courts when necessary, wherever and whenever a predatory parochialism or a local parasitic interest tries to flourish by obstructing the general commerce among the states. However, the danger is not over by any means. Only recently a group of manufacturers in the Southern States has become greatly concerned over the risk of spreading plant pests by means of used crates, and is considering the adoption of laws preventing the reuse of fruit and vegetable crates.

Some quarantines which are in reality trade barriers are forced upon quarantine officials by legislative action. At the same time, there exist in almost every state restrictive quarantines promulgated by the officials themselves, or adopted by

regulatory bodies upon recommendation of the quarantine inspector, which are trade barriers on a smaller scale. These include:

1. Quarantines restricting the entry of certain commodities from one state.
   on account of the presence of a plant pest, and not restricting entry from other states where the same pest is known to be established.
2. Quarantines imposed against another state on account of the presence of a certain pest when the pest in question is already established within the borders of the enacting state.
3. An embargo on one commodity on account of certain pests and then permitting other hosts to enter.

In passing, I will mention a few things that should NOT be done by state quarantine officials:

1. Inform a fellow quarantine officer that unless there were important economic circumstances involved, no change would be made in one of his quarantines.
2. Ask a fellow quarantine officer to certify to a misstatement in order to get around the provisions of one of his trade barrier quarantines.
3. Certify a nursery to be outside of an area quarantined on account of the presence of a certain pest, when the nursery in question is located within an infested and quarantined area.
4. Attempt to "cover up" the presence within his state of a major plant pest.

It will be noted that the preceding discussion has been confined to consideration of relations between state and federal plant pest control agencies. However, when we made inquiry concerning the relations of state and federal research workers, it was learned from the sources available that there was very little, if any, basis for criticism; at least in the states with which I am more or less familiar. I use the word "criticism" because our discussions of the pest control agencies' relationships have been of a somewhat critical character. Therefore, I am not indulging in any extensive comment regarding the relationship between state and federal research organizations. The situation in Florida, which would, of course, be our chief source of information, indicates that the state and federal agencies engaged in research work regarding insects are cooperating to the fullest degree.—3-11-40.

Federal-State Relations

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All that can be said on the subject of Federal-State relations may be summed up in just one word—people. Personalities, circumstances, conditions and traditions, and perhaps other factors, exert an influence on such relations but only in so far as the people concerned consciously or unconsciously are affected or influenced by them. Seldom if ever will the same circumstance, condition, or tradition exert the same influence or produce the same effect on two people. In view of the many combinations of such factors that may occur it appears that there are limitless chances of differences between those engaged in any cooperative undertaking. Considering that circumstances, conditions, and traditions may affect the same person from the official or from the personal angle, it begins to seem that infinity might be reached before the possibilities of differences were exhausted. Such reflections indicate the complexity of Federal-State relations and the advisability of drastic limitations on their consideration in this paper.

However, since Federal-State relations finally depend on personalities, we may wonder just what this discussion will accomplish. Changing human nature is not easy. Usually it requires a desire on the part of the person or persons concerned to be changed. Before wanting to be changed they probably would want to be convinced that a change was needed. Nearly everyone thinks he or she is a good cooperator and easy to get along with. Nevertheless, it is well known that there is a great difference between people in this regard. A good entomologist or

pathologist, or an excellent administrator, or a diligent worker, or even one possessing all these admirable qualities, if he is not cooperative may prove to be an obstacle rather than a help to a cooperative project. This emphasizes the desirability that those responsible for personnel selections in Federal-State activities give careful thought and full weight to the cooperative tendencies or record of the prospective employee.

That the problem is one primarily of people is evidenced by the fact that there are some instances of entirely satisfactory relationships between state and federal agents under the most trying conditions, while some instances of poor relationships under what would appear to be almost ideal conditions occur. Take the state official who says "I am the representative of my state in pest-control work. All federal funds expended in my state on pest control, eradication, and regulatory work should be turned over to me for expenditure since I have the authority to use the police power of the state, and through my organization the most effective use of federal funds can be made." It is true, he has the authority. Federal employees cannot work on non-federal land except through state authority. Of course it may be true that the state organization knows conditions in that state, where to go to get cooperation, and what steps to take to minimize opposition. Despite all these considerations it is well to remember that the federal government holds its employees responsible and that they cannot transfer the responsibility to state people along with the funds and authority. Furthermore, some programs involve action in a number of states, and adequate direction and coordination of the work in several states demand centralized authority and responsibility. This does not indicate lack of confidence in a given state official but it means that responsibility for federal funds belongs to federal employees and that a cooperative program should give full opportunity for state and federal officials to represent and protect the rights, privileges, and interests of their respective governments. There are times when differences seem clear-cut and important and at such times one or both has to yield in some measure, but if the personalities involved sincerely want to do what is right a compromise is found.

Of course we all know about the problem created by those personalities having personal ambitions. This phase of the matter is so thoroughly understood that we need not devote time to it. However, there is another type of personality that should possibly be included in this discussion. We all know those characters who want nothing specific for themselves but who are sincerely convinced that no one can meet a certain problem quite as well as they. We all know those many other types who are kept on for reasons other than strict efficiency. Most organizations have such persons, and even though they themselves may be highly cooperative their presence may lead to or add to situations which injure Federal-State relations. It not infrequently happens, when a new project is being set up in a state not previously concerned, thus bringing about new cooperative relations, that state officials indicate a desire to transfer to, or to have appointed on, federal rolls persons whom, they say, are capable of performing certain tasks or are possessed of certain valuable information necessary to the project. Frequently, but not always, these appraisals prove accurate. However, if we bear in mind that no two people react alike to events, contacts, and problems of the day's work, and that differences should be avoided in a field where personal relations are separated by a hair's breadth only, if at all, from official relations, it becomes clear that one very potent way of preserving harmonious Federal-State relations is through the exercise of scrupulous care by both agencies in the selection of personnel recommended for transfer to, or employment by, the other.

It was said previously that circumstances exert an influence on Federal-State relations. While this seems obvious, nevertheless circumstances alone are powerless to affect these relations except as the people concerned consciously or unconsciously react to them. There are too many circumstances thus influencing Federal-State relations for us to consider them all at this time. We should not omit, however, the question of funds, using the word funds in the broader sense of resources. Lack of funds may seriously cripple a project as we all know; in fact, some projects should not be carried on with resources of men, money, and equip-

ment below a certain minimum. On the other hand, there are projects which may make some progress even though their resources have been cut and recut far below the most practicable figure, to the great displeasure of those directly interested. Reduced rates of progress on some projects and inability to carry others because of lack of funds cause stress and strain on personalities, and this may, and often does, unfavorably affect Federal-State relations.

Too great a disparity in contributions as between federal and state governments sometimes leads to difficult relations. The most obvious way in which this circumstance operates is in creating an apologetic attitude on the part of the under contributor and a domineering attitude on the part of the other. These attitudes are frequently present only in the imagination of one of the cooperating parties, but, imaginary or real, their influence reacts consciously or unconsciously on personalities that even temporarily get into receptive moods. There are those who believe that control and eradication projects should be on a fifty-fifty basis. From the standpoint of getting work done promptly and most economically it is believed inadvisable to establish a hard-and-fast rule for federal and state participation on a cooperative project. On the other hand, there is no more potent argument in favor of a federal appropriation than that substantial contributions are being made by the states concerned. Signs have been noted indicating a growing tendency on the part of those responsible for federal appropriations to demand greater participation by cooperating agencies. It should be added, however, that in recent years, since emergency relief funds have been available, many projects have been largely carried by allocations of those funds. This may be a good time to say that if and when emergency relief funds are cut off or become less abundant, the federal appropriating agencies are very likely to inquire why a larger share of cooperative projects should not be borne by the individual states.

Before passing on to another phase of our subject opportunity is taken to point out that there are great differences between state and federal governments in the way they do things. In some states purchases of equipment and material or rent and similar items are more easily taken care of from state funds, in others it is found easier to furnish personnel, etc. Since the federal regulations apply equally in each state, the procedure naturally varies in accordance with state conditions, finances, and regulations. This situation may or may not affect Federal-State relations. Another phase of the problem is in the rates of pay of employees, permanence of employment, hours of labor, observance of holidays, and many other things. Such things are small when viewed from here but under the stress of a strenuous pest-control program they all exert an influence on Federal-State relations.

Now we come to the effect of conditions on Federal-State relations. Conditions encountered in the execution of a job exert a very definite influence on the worker and thus on Federal-State relations. Some work is difficult or distasteful to perform while other tasks are much easier or more pleasant. Some people have that peculiar quality which enables them to do even difficult tasks with seeming ease while others bog down with ordinary assignments. Work involving public contacts can be very trying. People are usually not backward about complaining about inefficient public servants, as for instance when they see a government or state truck broken down on the road. In such a case no one outside that particular service knows that this truck should have been retired before it had traveled the last 10,000 miles but that press of work and lack of funds to replace it prevented. If in a Federal-State cooperative pest-control program certain areas are sprayed with lead arsenate, every cow that takes sick and dies within miles is said to have arsenic poisoning. If we notify the property owner when we enter his property it takes half the day to answer all his questions, if we fail to notify him we get reported and it takes several days to write out all the explanations. These and many other examples are indicative of what is meant by the word "conditions." Everyone who has had any experience in pest-control work knows what effect such things have on the relations between workers and on those responsible for the program, and nothing could be more natural than for these conditions to be reflected in Federal-State relations. It does not necessarily follow, however, that

these conditions must affect the relations adversely. The many instances where the best relations persist despite some of the most trying conditions again indicate that personalities and their reactions to conditions are primarily responsible for relations that may occur.

Before concluding—what effect do traditions have on Federal-State relations? The word "traditions" carries with it the thought of age whereas many Federal-State projects are new or nearly so. It is believed that we only have to list some of the traditions we have in mind and that then further answer to this question will be unnecessary. You all know that old tradition on the part of the public that governmental employees, local, state, or national, have soft jobs with big pay and little to do. That tradition shows itself even today, in a variety of ways, through Federal-State relations. There are those state and local employees who think federal employees have badly inflated egos. As though the size of the political subdivision affects the caliber of the employee! This should not be worth mentioning but it is the source of trouble. If a state employee is a little peculiar in his dealings with his associates, that is described as "just his way," but if a federal employee acts similarly, "he has a swelled head." This is not a common difficulty but if it occurs at all it is too common because it reacts in a very unfortunate way on Federal-State relations. The personal reaction to personal annoyances may hit the surface in many different ways and may have far-reaching effects. Federal-State relations finally are personal relations. Little things as well as big ones affect such relations pleasantly or unpleasantly, consciously or unconsciously.

This being the situation, what are we to do about it? The answer is not hard to find. Since it all hinges on the people concerned, let those responsible for selecting personnel for Federal-State cooperative jobs give utmost attention to their cooperative tendencies and record. Let them follow this up with careful supervision to detect as quickly as possible initial evidences of the development of friction. When they find such evidences let them study the situation impartially, searching for the cause of the trouble regardless of whom it might affect rather than searching for evidence tending to clear their man while incriminating the other one. When one considers the large number of people engaged in these cooperative enterprises and the many obstacles to cooperation it speaks most highly for those involved that Federal-State relations have been and are generally so fine.—3-11-40.

Insecticides for Boll Weevil Control

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The tests here reported, in which several insecticides were compared as to their effectiveness in boll weevil control, were conducted during 1939 in Madison Parish, La., within a 10-mile radius of Tallulah. The plots were either 20 or 22 rows in width and were of sufficient length so that each plot contained one-fourth acre or more, and were arranged in randomized blocks. Buffer areas of five rows on each side and 17.5 feet or more on each end of each plot were eliminated; this left an area of one-tenth of an acre in which cotton was picked. Since it was not possible to obtain the desired number of replications in one field, it was necessary to use either two or three fields in each series of tests.

In each plot infestation records were made by examining 300 squares, 100 at the center and 100 near each end. Each infestation given in this paper is the average percentage of squares punctured after treatments were begun. The yield record given is the average yield per plot. An accurate record was made of the quantity of poison applied to each plot by weighing the hand dust gun before an application was begun and again after it was completed. All treatments were begun when the square infestation was approximately 10 per cent. The sulfur in plot D, Series

[1] The authors were assisted in the field by H. C. Massey, C. A. Richmond, H. W. Frings, and R. W. Goins.

IV, was applied at 7-day intervals, whereas all the remaining insecticides or mixtures used were applied at either 4- or 5-day intervals. The treatment applications, except midday and late afternoon application in Series I (Table 1), were made early in the morning when the plants were usually wet with dew and the atmosphere was calm. Whenever a treatment was washed off within 24 hours after application it was considered ineffective and another was made as soon as possible.

Table 1.—Records of boll weevil infestation and cotton yield obtained from plots dusted with calcium arsenate at different times of the day (Series I).

Time of Day	Average Infestation, Per Cent	Yield (1/10 Acre), Pounds
Early morning	12.6	231
Midday	22.4	226
Late afternoon	20.6	217
No treatment (check)	34.9	181
Minimum significant difference at 5% level	6.5	33
Minimum significant difference at 1% level	9.8	50

All plots, except those in one field which had a very low infestation, were treated for control of aphids. They were dusted with a mixture of lime and nicotine sulfate containing approximately 3 per cent of nicotine.

After treatments were begun, sampling data on infestations, recorded as percentages of squares punctured, were obtained. These data, together with those for yields, expressed as pounds of seed cotton per plot, were statistically analyzed. Although the infestation percentages were transformed to equivalent angles, the conclusions from the angles were identical with those from the percentages. Analyses of variance of infestations and of yields for each of the series are presented in table 6. Required significant differences at probabilities of 19 to 1 and 99 to 1 are included in all tables.

In each series of tests the letter A was used to designate the untreated check plots and B to designate those plots treated with calcium arsenate, while the remaining letters designate the treated plots that were compared with A and B in each particular series.

The Most Effective Time of Day for Dusting (Series I).—The plots of this series were located in two fields and consisted of four applications. From July 18 to August 14 each of the treated plots received eight replications, seven of which were effective. The applications (Table 1) on four of the plots were made early in the morning, on another group of four near midday, and on the third group late in the afternoon, whereas the last group received no treatment. An average of 5.7 pounds of calcium arsenate per acre per application was applied on all treated plots. That calcium arsenate contained 4.6 per cent of water-soluble arsenic pentoxide by the New York method.[2]

The plots dusted early in the morning (Table 1) showed a significant decrease in infestation over plots dusted later in the day. All treated plots showed highly significant decreases in infestation and significant increases in yield when compared with the untreated plots.

Comparisons of Cryolites and Calcium Arsenate (Series II).—Cryolite Mixture No. 1 (Table 2) contained 18.4 per cent of fluorine corresponding to 33.8 per cent of sodium fluoaluminate (Na_3AlF_6), cryolite No. 2 contained 48.5 per cent of fluorine corresponding to 89.3 per cent of sodium fluoaluminate, and the calcium arsenate contained 3.5 per cent of water-soluble arsenic pentoxide by the New York method. In one field with three replications plots B, C, and E received eight applications from July 14 to August 15, one of which was washed off by rain. In plots treated with cryolite No. 2 (D) the third application burned the foliage so severely that no additional treatments were made. Although light burning of foliage was caused by cryolite No. 2 to which 1 per cent of the sticker and spreader *Lethane* had been added (plot E), it was not necessary to discontinue treatments. In another field with two replications six effective applications were made on the plots from July 15 to August 10. Light burning was caused by some of the treatments with cryolite No. 2, but no burning was noted from those made on plots treated with the cryolite No. 2 containing a sticker and spreader. The average quantities of poison used per acre

[2] All chemical analyses of insecticides reported in this paper were made by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine.

on plots B, C, D, and E were 5.7, 15.7, 14.5, and 14.6 pounds, respectively, applied in each field on the same dates at approximately the same time of day.

The calcium arsenate treatment (Table 2) was followed by a highly significant reduction in infestation as compared with the untreated check. Although treatments with cryolite No. 2 plus 1 per cent of *Lethane* reduced the infestation by 13.1 per cent from the check, this difference was barely significant. Nearly the same reduction (13.4 per cent) in infestation was observed following the calcium arsenate treatment as compared with cryolite mixture No. 1. The yield from plots treated with cryolite No. 2 was significantly lower than that from any of the other treated plots. In interpreting these records it must be remembered, however, that cryolite No. 2 caused severe burning of foliage in one of the fields and light burning in the other.

CALCIUM ARSENATE PLUS SULFUR AND CALCIUM ARSENATE ALONE (SERIES III).—The calcium arsenate (Table 3) used in the factory-prepared calcium arsenate and sulfur mixture 1:2 was of the same brand as that used for the applications of calcium arsenate alone which contained 3.5 per cent of water-soluble arsenic pentoxide by the New York method. Conditioned dusting sulfur, 98 to 100 per cent passing through 325-mesh screen, was used in the mixture. The mixture was applied in the place of the calcium arsenate at a rate that would use 5.1 pounds of calcium arsenate and 10.2 pounds of sulfur per acre at each application. The experimental plots were located in three fields and were replicated nine times. All the treated plots in a field were dusted on the same dates. The period of treatment in two of the fields extended from July 20 to August 22. Nine treatments, eight of which were effective, were made on each of these plots. Instead of calcium arsenate the mixture was applied once (on July 20) on the plots designated as D and three times (July 20 and 31 and August 8) on those designated as C. In the third field the period of dusting extended from July 14 to August 21. During this period 10 applications were made, 8 of which were effective and two were washed off by rain. The one application of the mixture on the D plots was made on July 14, while the dates of application of the mixture on the C plots were July 14 and August 1 and 11. The B plots in all fields were dusted with calcium arsenate alone, while the check plots (A) received no treatment. The average quantities of calcium arsenate, alone and in the mixture, used per acre per application on all the B, C, and D plots were 5.9, 5.6, and 5.6 pounds.

From table 3 it is seen that following all treatments there were highly significant reductions in infestation and significant increases in yield as compared with the untreated plots. The application of the mixtures failed to result in significant differences in either infestation or yield, in the plots thus treated, from the plots treated with calcium arsenate alone.

Table 2.—Records of boll weevil infestation and cotton yield obtained from plots dusted with calcium arsenate and from those dusted with cryolites with and without a sticker and spreader (Series II).

TREATMENT	AVERAGE INFESTATION, PER CENT	YIELD (1/10 ACRE), POUNDS
(B) Calcium arsenate	15.8	195
(C) Cryolite Mixture No. 1	29.2	180
(E) Cryolite No. 2+1% of *Lethane*	25.6	180
(A) Check	38.7	164
(D) Cryolite No. 2	27.6	153
Minimum significant difference at 5% level	12.3	22
Minimum significant difference at 1% level	17.3	31

Table 3.—Records of boll weevil infestation and cotton yield obtained from plots in which a calcium arsenate-and-sulfur mixture was substituted for calcium arsenate in some of the applications (Series III).

TREATMENT	AVERAGE INFESTATION, PER CENT	YIELD (1/10 ACRE), POUNDS
(D) Calcium arsenate mixture* 1 application	21.7	238
(C) Calcium arsenate mixture* 3 applications	25.9	238
(B) Calcium arsenate	24.1	234
(A) Check	43.8	215
Minimum significant difference at 5% level	6.8	17
Minimum significant difference at 1% level	9.3	24

* Calcium arsenate and sulfur 1:2.

SULFUR AND CALCIUM ARSENATE, SULFUR ALONE, AND CALCIUM ARSENATE ALONE (SERIES IV).—The same brands of calcium arsenate and dusting sulfur that were used separately for treating the B and D plots of table 4 were used in preparation of the two mixtures at the factory. The calcium arsenate used on the B plots contained 3.5 per cent of water-soluble arsenic pentoxide by the New York method. Conditioned dusting sulfur, 98 to 100 per cent passing through 325-mesh screen, was used for treating D plots and in the mixtures. Two replications were located in one field and three in another. In each field six effective treatments were made on plots B, C, and E, from July 15 to August 10. The average quantities of poison used on the B, C, and E plots were 5.8, 13.9, and 14.0 pounds per acre per application respectively. The D plots received effective sulfur treatments on July 15, 22, and 31. The average quantity of sulfur used was 14.2 pounds per acre per application. In table 4 are given the infestation and yield results, together with the statistical interpretations.

In table 4, also, certain independent comparisons are shown, whereby the effect of sulfur and of calcium arsenate in this series has been studied. The third comparison, B versus C and E, shows the effect of sulfur. The differences of 1.8 per cent in infestation and of 5 pounds in yield were not significant. The fourth comparison, A and D versus B, C, and E, shows the effect of calcium arsenate in this series. The infestations in these two groups differed significantly at the 1 per cent level while the nonsignificant difference in yield was 13 pounds per plot in favor of the group in which calcium arsenate was used, either alone or mixed with sulfur.

The weighted average yield for the calcium arsenate treatments in plots B in Series III and IV was 228 pounds per plot. The weighted average for plots C and D in Series III and plots C and E in Series IV was 229 pounds. The difference between the average yield for plots treated with calcium arsenate alone and the average for plots treated with calcium arsenate and sulfur was only 1 pound per plot, or 10 pounds per acre.

CALCIUM ARSENATE WITH AND WITHOUT A 5 PER CENT STICKER (SERIES V).—The calcium arsenates (Table 5) used in all plots were of the same brand. The calcium arsenate without the sticker, used in plots B, contained from 1.6 to 2.0 per cent of water-soluble arsenic pentoxide as determined by the New York method and from 43.1 to 43.3 per cent total arsenic pentoxide. The calcium arsenate containing the 5 per cent sticker, used in plots C, contained from 0.13 to 0.23 per cent of water-soluble arsenic pentoxide as determined by the New York method and from 42.18 to 43.42 per cent of total arsenic pentoxide. Three fields, with two replicates in each, were used. In each field the plots were treated on the same dates, as nearly as possible the same quantity (6.1 and 6.4 pounds) of calcium arsenate being used per acre per application. Six effective applications, extending from July 15 to August 10, were made in one field. In another field nine applica-

Table 4.—Records of boll weevil infestation and cotton yield, and independent comparisons of the same, obtained from plots treated with calcium arsenate alone, with sulfur alone, and with mixtures of these materials in various proportions (Series IV).

Treatment	Average Infestation, Per Cent	Yield (1/10 Acre), Pounds	Analysis of Variance				
			Comparison	Infestation Difference, Per Cent	Infestation Mean Square	Yield (1/10 Acre) Difference, Pounds	Yield (1/10 Acre) Mean Square
(C) Calcium arsenate and sulfur 1:1	14.0	221	A vs. D	5.3	69.70	16	624.10
(B) Calcium arsenate	11.9	218	C vs. E	.7	1.52	15	562.50
(A) Check	24.7	210	B vs. C and E	1.8	9.98	5	93.63
(E) Calcium arsenate and sulfur 1:2	13.3	206	A and D vs. B, C, and E	8.9	480.25*	13	1,040.16
(D) Sulfur	19.4	194					

* Highly significant.

tions, of which eight were effective, were made from July 20 to August 22. In the remaining field eight applications, of which four were effective, were made from July 21 to August 12.

The addition of the sticker to the calcium arsenate (Table 5) failed to result in a significant reduction in infestation in plots in which this treatment was used as compared with plots treated with calcium arsenate alone. Both treatments, however, gave highly significant reductions in infestation over the checks.

Table 5.—Records of boll weevil infestation and yield obtained from plots treated with calcium arsenate with and without a sticker (Series V).

TREATMENT	AVERAGE INFESTATION, PER CENT	YIELD (1/10 ACRE), POUNDS
(B) Calcium arsenate without sticker	19.7	238
(C) Calcium arsenate with 5% sticker	16.4	237
(A) Check	42.3	223
Minimum significant difference at 5% level	13.4	—
Minimum significant difference at 1% level	20.2	—

sufficient length so that each plot contained one-fourth acre or more, and were arranged in randomized blocks. When buffer areas were eliminated in each plot an area of one-tenth acre was left in which cotton was picked. Infestation records were made in each plot by examining 300 squares, 100 at the center and 100 near each end. An accurate record was made of the quantity of poison applied to each treated plot. In the five series of tests the average quantity of calcium arsenate applied at each dusting ranged from 5.6 to 6.4 pounds per acre. The average quantity of the cryolites, sulfur and the two calcium arsenate-sulfur mixtures applied at each dusting was approximately 15 pounds per acre.

The plots dusted early in the morning showed a significant decrease in infestation over plots dusted at midday and late in the afternoon but there were no significant differences among the yields. The plots treated early in the morning, at midday, and late in the afternoon all showed highly significant decreases in infestation and significant increases in yield when compared with the untreated plots. Calcium arsenate showed a greater decrease in infestation and a greater increase in yield than either of the cryolites tested. One of the cryolites caused severe burning of foliage. That cryolite, when 1 per cent of the sticker and spreader

Table 6.—A summary of the analyses of variance of the records of boll weevil infestation and cotton yield for all series of tests.

	INFESTATION									
	Series I		Series II		Series III		Series IV		Series V	
SOURCE OF VARIATION	Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square	Degrees of Freedom	Mean Square
Treatments	3	342.09†	4	334.20*	3	920.50†	4	140.36†	2	1,195.05†
Fields	1	433.68	1	226.80	2	1,443.67	1	2,134.95	2	726.54
Treatment-field discrepance	3	124.76	4	187.83	6	87.71	4	36.87	4	89.96
Blocks	2	162.18	3	60.33	6	39.79	3	9.59	3	135.60
Pooled treatment-block discrepance (Error)	6	13.95	12	80.32	18	47.13	12	22.69	6	89.41
Total	15		24		35		24		17	
	YIELD									
Treatments	3	2,014.00*	4	1,295.50*	3	1,033.00*	4	580.00	2	409.5
Fields	1	8,930.00	1	17,517.00	2	26,983.00	1	937.00	2	5,008.0
Treatment-field discrepance	3	150.67	4	301.25	6	349.00	4	85.50	4	273.5
Blocks	2	6,782.50	3	1,174.67	6	2,624.83	3	38.00	3	391.7
Pooled treatment-block discrepance (Error)	6	367.67	12	263.83	18	303.00	12	238.00	6	259.7
Total	15		24		35		24		17	

* Significant.
† Highly significant.

SUMMARY.—Several insecticides were tested for boll weevil control in Madison Parish, La., in 1939. The test plots were either 20 or 22 rows in width and were of

Lethane had been added, caused very light burning of foliage, a slight decrease in infestation, and a significant increase in yield when compared with cryolite alone. Calcium arsenate and mixtures of calcium arsenate and sulfur were about equal in effectiveness. Calcium arsenate and calcium arsenate plus 5 per cent of sticker gave equally good control.—4-15-40.

Effect of Insecticides Used in Boll Weevil Control Upon Aphids and Mirids

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In many tests in boll weevil control, aphids, *Aphis gossypii* Glov., develop to injurious numbers following the use of certain insecticides and greatly complicate the interpretation of results. The results are also further complicated by the presence of two mirids, the tarnished plant bug, *Lygus pratensis oblincatus* (Say) and the rapid plant bug, *Adelphocoris rapidus* (Say). The purposes of the studies in Madison Parish, La., during 1939 were to determine the effect of certain insecticides tested for boll weevil control upon aphid and mirid infestations and to determine the injury caused by aphids.

METHODS.—Counts of aphids were made by examining 1 square inch of leaf area on the fourth leaf from the top of a cotton plant without removing the leaf from the plant. In each plot 100 plants were selected, affording 100 square inches of leaf area for sampling purposes. The area examined for aphids and the plants used were both selected at random. This method of determining aphid infestations is a modification of those described by J. C. Gaines (1937) and by Dunnam & Clark (1938). Counts in all the tests were made on either five or six dates during the period July 26 to September 1. Counts were made before and after a mixture of nicotine sulfate and lime was applied for aphid control, and the averages of these counts are presented in the tables which follow. Counts of the numbers of adults and nymphs of the tarnished plant bug and the rapid plant bug were also made in some of the series. The sweeping and the hoop-and-bag methods were used to capture the mirids. The data were studied statistically by the method of analysis of variance. The treatments for boll weevil control in all series were made from July 13 to August 10.

COUNTS OF APHIDS ON CALCIUM ARSENATE PLOTS.—In Series XIV, the results of which are summarized in table 1, the treatments consisted of calcium arsenate containing on an average 0.5 , 4.6, and 10.3 per cent of water-soluble arsenic pentoxide as determined by the New York method.[2] These calcium arsenates have been designated as low, intermediate, and high, respectively. It is interesting to note that a significantly larger number of aphids were found in the plots treated with calcium arsenate containing a high percentage of water-soluble arsenic pentoxide than in plots treated with a calcium arsenate containing a low percentage. There were no other significant differences between the insecticidal treat-

Table 1.—The significance of aphid counts collected from cotton leaves on plots receiving different insecticidal treatments (Series XIV).

Treatment	Aphids per Square Inch of Leaf Area, Number	Analysis of Variance		
		Source of Variation	Degrees of Freedom	Mean Square
Calcium arsenate, high	1.95	Blocks	4	0.3870
Calcium arsenate, intermediate	1.84	Treatments	3	2.3203*
Calcium arsenate, low	1.40	Error	12	.1267
Check	.45	Total	19	
Minimum significant difference at the 5% level	.49			
Minimum significant difference at the 1% level	.69			

* Highly significant.

[1] The authors were assisted in the field by G. L. Garrison, A. L. Scales, C. A. Richmond, H. C. Massey, H. W. Frings, G. C. Woodruff, J. A. Fontenot, and W. H. Richardson.

[2] All chemical analyses were furnished by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine.

ments. The average yield in plots treated with the calcium arsenate containing a low percentage of water-soluble arsenic pentoxide was 66 pounds of seed cotton per acre more than in plots treated with the calcium arsenate containing a high percentage. The difference in aphid infestations may partly explain the difference in yield since cage and laboratory tests have indicated that the calcium arsenate containing a high percentage of water-soluble arsenic pentoxide was more effective and toxic against the boll weevil than the one containing a low percentage.

great variations in the number of aphids found in the plots receiving the different treatments, more aphids being found in the plots treated with the most effective insecticides and fewer being found in the plots treated with the least effective insecticides for the boll weevil.

The data in table 2 afford several comparisons. Two groups have been made on the basis of yields. The yields from plots receiving treatments D and C were smaller than the yield from the check plot, and the yields from plots receiving treatments B, F, and E were larger than the

Table 2.—Sampling records obtained from plots and cages in which the cotton plants were dusted with insecticides for boll weevil control (Series XIII).

Treatment	Average Boll Weevil Infestation Per Cent	Net Mortality of Boll Weevils in Cages, Per Cent	Number of Aphids per Square Inch of Leaf Area	Yield per Plot (1/53 Acre), Pounds
(D) Di-calcium arsenate, $CaHAsO_4 \cdot H_2O$	16.9	89	3.65	45.4
(C) Mixture C (2.6%*) {7% paris green, 93% calcium arsenate}	18.2	66	2.17	47.0
Weighted average	17.6	78	2.91	46.2
(B) Calcium arsenate (3.4%*)	15.6	68	2.32	48.6
(F) Imported calcium arsenate (0.35%*)	17.7	56	1.98	48.3
(E) Basic copper arsenate, $Cu(CuOH)(AsO_4)$	19.1	48	1.27	50.1
Weighted average	17.5	58	1.86	49.0
(A) Check	25.5	—	.48	47.1
†Minimum significant difference at 5% level			.51	
Minimum significant difference at 1% level			.70	

* Water-soluble arsenic pentoxide as determined by the New York method.
† Averages not included.

COUNTS OF APHIDS IN SERIES XIII.—The di-calcium arsenate used in this Series (Table 2) was prepared by the Division of Insecticide Investigations and was practically pure $CaHAsO_4 \cdot H_2O$, containing 57.1 per cent of total arsenic pentoxide, 28.4 per cent of calcium oxide, and 13 per cent of water. The basic copper arsenate contained 0.08 per cent of water-soluble arsenic pentoxide by the A.O.A.C. method, 38.4 per cent of total arsenic pentoxide, and 54.4 per cent of cupric oxide. The percentages of water-soluble arsenic pentoxide found in Mixture C and in the two calcium arsenates are given in table 2.

In this series insecticides were included which varied greatly in their effectiveness against the boll weevil in cage tests. It will also be noted that there were

yield from the check. The difference between the average yield in plots D and C and the average yield in plots B, F, and E was 148 pounds of seed cotton per acre. The difference between the lowest average yield, which was in the di-calcium arsenate plots (D), and the highest average yield, which was in the basic copper arsenate plots (E), was 249 pounds per acre. Aphid infestations appeared partly to explain these differences in yield because there was a light boll weevil infestation in all plots and very small differences between the average infestations in the various plots receiving poison treatments. The variation in yields caused by the boll weevil did not appear to be important. The coefficient of correlation between the average number of aphids found per square inch of leaf area and yield, with

Table 3.—Average cotton yield in pounds per plot (1/10 acre), in Series XII, in which the plots were dusted for the boll weevil, for aphids, or for both.

Aphid Control	Boll Weevil Control: None	Boll Weevil Control: Calcium Arsenate	Average
None	A 199	B 213	206
Nicotine sulfate-lime mixture	D 203	C 226	215
Average	201	220	

checks included, was −.52 (P more than .10) and without the checks the coefficient was −.92 (P approximately .02). The correlation coefficient between the average number of aphids found per square inch of leaf area and net mortality of boll weevils in cages was +.99 (P more than .01). These coefficients leave little doubt as to the relation between aphid infestations and effectiveness of insecticides, and between aphid infestations and yields.

THE EFFECT OF APHIDS AND BOLL WEEVILS ON COTTON YIELDS.—Series XII was a factorial experiment (Table 3) to determine the effect of aphid control on yield, the effect of boll weevil control on yield, and the effect of a combination of both aphid and boll weevil control on yield. A mixture of nicotine sulfate and lime containing approximately 3 per cent of nicotine was used as needed for aphid control. In one field this mixture was applied on August 8 and 31 and in the other two on August 21. Observations indicated that good control was obtained by the applications. Calcium arsenate which contained 3.5 per cent water-soluble arsenic pentoxide by the New York method was used for boll weevil control. In table 4 the results of statistical analysis of the factorial experiment are given. The highly significant average increase caused by boll weevil control, with and without aphid control, was 190 pounds of seed cotton per acre, while the nonsignificant average increase caused by aphid control, with and without boll weevil control, was 90 pounds. In the absence of aphid control the nonsignificant average increase caused by boll weevil control was 140 pounds per acre, while with aphid control the average increase of 230 pounds was significant. In the absence of boll weevil control the average increase caused by aphid control was 40 pounds per acre, while with boll weevil control the average increase was 130 pounds, both differences being nonsignificant. The highly significant average increase of 270 pounds per acre was caused by the combination of both boll weevil control and aphid control.

Table 4.—Analysis of variance of cotton yields in Series XII, in which the plots were dusted for aphids, for the boll weevil, or for both.

Source of Variation	Degrees of Freedom	Mean Square
Treatments:		
Aphid control, A and B vs. D and C	1	480.57
Boll weevil control, A and D vs. B and C	1	2,451.57*
Interaction	1	146.29
Fields	2	980.00
Treatment×field	6	307.33
Blocks	4	624.25
Pooled treatment-block discrepance (error)	12	216.25
Total	27	

* Highly significant.

Table 5.—Counts of aphids in Series X, in which the plots were dusted with calcium arsenate, with and without sulfur.

Treatment	Number of Aphids per Square Inch of Leaf Area	Consecutive Differences
Calcium arsenate,* 4 to 6 lbs. per acre	0.65	—
Calcium arsenate and sulfur 1:1, 4 to 6 lbs. per acre	.62	0.03
Calcium arsenate,* 2 to 3 lbs. per acre	.51	.11
Check	.16	.35
Minimum significant difference at 5% level		.26
Minimum significant difference at 1% level		.40

* Contained 3.5 per cent water-soluble arsenic pentoxide by the New York method and the calcium arsenate in the mixture was of the same brand. Conditioned dusting sulfur, 98 to 100 per cent passing through 325-mesh screen, was used in the mixture.

COUNTS OF APHIDS IN SERIES X.—In Series X (Table 5) there were no significant differences in the aphid counts

between the averages for the treated plots. The counts made in this series indicated that calcium arsenate greatly increased the number of aphids found, but that sulfur apparently had little or no effect upon the number found.

COUNTS OF APHIDS AND MIRIDS IN SERIES IV.—The total numbers of adults and nymphs of the tarnished plant bug and the rapid plant bug taken per plot on July 21, July 27 and August 4 by the two methods are given for each treatment and check in table 6.

Table 6.—Counts of mirids and aphids in Series IV, in which the plots were dusted with calcium arsenate, with sulfur, and with both for boll weevil control.

TREATMENT	NUMBER OF MIRIDS TAKEN	NUMBER OF APHIDS PER SQUARE INCH OF LEAF AREA
(A) Check	71	0.37
(B) Calcium arsenate*	48	1.00
(D) Sulfur	41	.60
(C) Calcium arsenate and sulfur 1:1	41	.99
(E) Calcium arsenate and sulfur 1:2	35	1.15

* Contained 3.5 per cent of water-soluble arsenic pentoxide as determined by the New York method and the calcium arsenate used in the mixtures (C) and (E) was of same brand. Conditioned dusting sulfur, 98 to 100 per cent passing through 325-mesh screen, was used for treating the (D) plots and in the mixtures (C) and (E).

In table 7 independent comparisons have been made to show the effect of calcium arsenate and of sulfur upon the aphid and mirid infestations. In the first comparison the average number of aphids found in check plots A and the average number found in sulfur plots D did not differ significantly. In another comparison the average number of aphids found in calcium arsenate plots B and the average number found in the calcium arsenate-sulfur mixture plots C and E as a group did not differ significantly, which indicates that the addition of sulfur to calcium arsenate apparently had little or no effect upon aphid infestation. The average number of aphids for plots A and D, which received no calcium arsenate, was compared with the average for plots B, C, and E, all of which received calcium arsenate either alone or mixed with sulfur. A significant difference at the 1 per cent level between the groups was found. These records indicated that calcium arsenate was the only material in this series of tests which greatly affected aphid infestations.

The difference between the average mirid infestation for plots A and the average for plots D was significant at the 1 per cent level. The difference between the average for plots B and the average for plots C and E as a group was not significant. The difference of 14 between the average number of mirids for plots A and D and the average for plots B, C, and E was significant at the 1 per cent level. The records made in this one series indicated that calcium arsenate alone was sufficiently effective against light infestations of the tarnished plant bug and the rapid plant bug and that the addition of sulfur to calcium arsenate was

Table 7.—Analyses of variance of counts of aphids and of mirids in Series IV and X.

SOURCE OF VARIATION	SERIES IV			SERIES X	
	Degrees of Freedom	Mean Square		Degrees of Freedom	Mean Square
		Aphids	Mirids		Aphids
Treatments:				3	0.2014*
A vs. D	1	0.1277	2,160.90†	—	—
C vs. E	1	.0672	96.10	—	—
B vs. C and E	1	.0154	326.70	—	—
A and D vs. B, C, and E	1	1.8704†	1,226.94†	—	—
Fields	1	7.7748	576.24	1	.3052
Treatment×field	4	.2680	17.97	3	.0134
Blocks	3	.0282	114.00	2	.0721
Pooled treatment—block discrepance (error)	12	.0921	124.73	6	.0232
Total	24			15	

* Significant.
† Highly significant.

not necessary. These records also indicated that calcium arsenate alone, sulfur alone and mixtures of sulfur and calcium arsenate did not differ significantly in their effectiveness against light infestations of these two mirids.

SUMMARY.—Aphids usually increased in numbers following applications of calcium arsenate. A larger number of aphids was found in plots treated with calcium arsenate containing 10.3 per cent of water-soluble arsenic pentoxide by the New York method than in plots treated with calcium arsenate containing 0.5 per cent, the number found in plots treated with a calcium arsenate containing 4.6 per cent falling between the other two. Sulfur appeared to have little or no effect upon aphid infestations. There was a definite correlation between aphid infestations and yields and between aphid infestations and effectiveness of insecticides against boll weevils in cages. The reduction in yields caused by aphids is of much importance. In one series of tests calcium arsenate was sufficiently effective to control light infestations of the tarnished plant bug and the rapid plant bug without the addition of sulphur to the dusting mixture.—4-15-40.

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Spur-Burrowing Habit of Codling-Moth Larvae on Pear Trees*

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In the Rogue River Valley there has been an increasing occurrence of burrowing in pear fruit spurs by larvae resembling those of the codling moth, which caused the writer to make an effort to establish the identity of the insect. Such varieties as Bosc and Anjou, having large "fleshy" spurs, seemed to be especially subject to such injury. Larvae were found in the spurs both during the growing season and after the fruit had been harvested. A total of ten spurs containing larvae were placed in cages in the laboratory and from these it was possible to rear two adults, which were identified by the writer as those of the codling moth, *Carpocapsa pomonella* (L.).[1] The phase of codling-moth activity discussed in this article is of considerable importance to the pear industry, and should be brought to the attention of other investigators.

HISTORY.—It is not definitely known just how long injury of this type has been occurring, but for a number of years prior to 1936 the men taking care of the experiment-station orchard had at various times reported the finding of fruit spurs on Anjou trees that appeared as if codling-moth larvae had burrowed in them. However, at the time these reports were made, no evidence could be found to indicate the kind of larva which had caused the injury.

In the fall of 1936, while the writer was examining Bosc pears for worm injury at harvest time, one of the pickers found a spur with frass attached to the end. An examination disclosed that this spur contained a half-grown larva closely resembling that of the codling moth. The larva was placed in a fresh spur in a cage in the laboratory. By October 3 it had cocooned within some corrugated paper in the cage. Some time prior to June 12, 1937, an adult codling moth emerged from the cocoon, definitely establishing the identity of the larva attacking pear fruit spurs.

An examination of trees in well-sprayed orchards in different parts of the valley revealed that fruit spurs of Bosc and Anjou trees with larval injury could be found quite generally. On about 30 trees

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[1] The determination was kindly verified by Mr. Carl Heinrich of the Division of Insect Identification, U. S. Bureau of Entomology and Plant Quarantine.

examined in one eleven-acre Bosc orchard, from 6 to 12 such spurs were found per tree, among those that could be reached from the ground.

On September 23, three and one-half weeks after harvest, the spurs of an unsprayed Bosc check tree in the experiment-station orchard were examined for injury. There were 251 fruit spurs on this tree at that time, in which larvae had recently burrowed or were still at work. Some of the larvae were quite large, others only about 4 or 5 days old, which indicated that they had entered after the fruit was picked. In addition to these, at least 15 spurs were found in which larvae had worked earlier in the season, probably during the first-brood period. Blackened, partly-grown, mummified fruits were still adhering to most of these, and masses of frass were still evident at the points of entrance (Figs. 1 and 2).

Investigations during 1937 and 1938 showed that it was not uncommon to find

FIG. 1.—Partly grown, mummified Bosc pear on fruit spur after harvest. Larva entered at junction of stem and spur. Two outer leaves dead. Reduced about one fourth.

FIG. 2.—Partly grown, mummified Bosc pear on fruit spur after harvest. Larva entered through scar where fruit stem had separated from spur. Reduced about one half.

larvae working in fruit spurs of pear trees, both in the first- and the second-brood periods, in spite of the fact that the trees were bearing a good crop of fruit.

In 1938 the men who were cutting fire blight in the station orchard noticed

FIG. 3.—Bosc fruit spur showing extent of larval burrow. Photographed June 27, 1938, during first-brood period. Slightly reduced.

quite a few Anjou and Bosc spurs with worms working in them on which the fruit had shrivelled and turned black, having the appearance of being blighted. One of these spurs found on June 27 (Fig. 3) contained a nearly full-grown larva, which was placed in a fresh spur in a cage in the laboratory. The larva soon constructed a cocoon within the spur, and some time prior to July 30 it had changed to an adult codling moth.

The adults reared from spurs were somewhat smaller than those developing from larvae which had fed on fruit under normal orchard conditions, but otherwise there seemed to be no difference. It is not known whether the smaller size was due to the type of food consumed or to the fact that the spurs had been removed from

the trees and were brought into the laboratory where they did not receive the natural food supply from the tree.

Many codling-moth eggs are often found on pear trees at harvest time, from which young larvae emerge after all of the

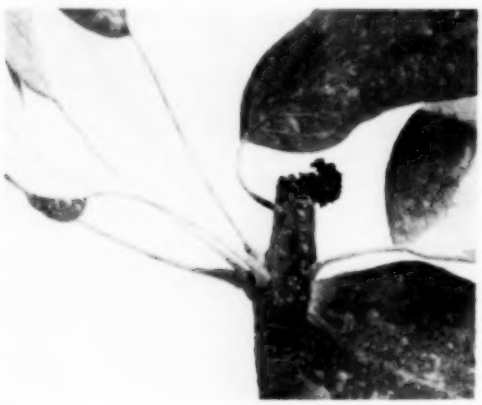

FIG. 4.—Fruit spur of Bosc pear tree after harvest, with codling-moth larva burrowing within. Leaf near tip dead. Slightly reduced.

FIG. 5.—Bosc fruit spur showing frass at tip, and two leaves killed by larva working in spur. Photographed October 5, 1936. Natural size.

fruit has been removed. Since there is no fruit present at that time within which these young larvae can feed, it is necessary that they seek other food material in order to keep from starving. The "fleshy" fruit spurs, which contain considerable starchy matter, seem to answer the purpose, since the larvae burrow into these and feed within. It still remains to be proven whether or not the progeny of moths coming from spur-worms may have developed a taste for fruit spurs instead of the fruit, thus establishing a spur-burrowing strain of codling-moth larvae. The fact that an appreciable number of young larvae may enter fruit spurs to which fruits are attached, during the growing season, points to the possible existence of such a strain.

VARIETIES ATTACKED.—Spur-burrowing has been noted chiefly on Bosc and Anjou varieties. Occasionally a larva may be found in a Bartlett spur, but the spurs of Bartlett trees are smaller and may not be as suitable as those of Bosc or Anjou.

NATURE OF PEAR FRUIT SPURS.—The pear fruit spurs are large and of a rather soft or "fleshy" texture as compared with the woody structure of the twig proper. No doubt they are rich in starchy materials and contain food enough to permit the larvae to reach maturity and develop to the adult stage.

Bosc spurs may be from an inch to one and three-quarters inches in length and from one-fourth to three-eighths of an inch in diameter at the widest part.

Anjou spurs are shorter and wider, somewhat urn-shaped. They may be from five-eighths to one and three-sixteenths inches in length and from three-eighths to five-eighths of an inch in diameter at the widest part.

POINTS OF ENTRANCE.—During the growing period, when the fruit crop is on the tree, the larvae usually enter the spur by burrowing in through the scar remaining when a fruit stem has separated from the spur (Fig. 2). Occasionally one may enter at the junction of the stem and the spur (Fig. 1), or in the axil of a leaf attached to the spur.

After the fruit has been harvested, practically all larvae enter where the fruit stem has separated from the spur (Figs. 4 and 5).

NATURE OF INJURY.—The larvae may tunnel the spurs for a considerable distance, until they reach the woody portion, completely eating out the inside portion of the spurs. The longest burrow observed extended for a distance of one and five-eighths inches from the tip (Fig. 3). The burrows extend past young shoots, and leaf and fruit buds which grow from near

the tips of the spurs, and certainly this tunnelling tends to weaken these.

The feeding of the larvae in spurs cuts off the food supply from the fruits, and from the leaves near the tip of the spur. If the fruits are only partly grown when this occurs, they shrivel and turn black, appearing as if killed by fire blight (Figs. 1 and 2). These mummified pears may fall to the ground later, but many of them may still be found on the trees after the fruit has been harvested. Two and three such pears may occur on a single spur. In a sprayed orchard of rather young Bosc trees as many as 10 to 12 such spurs could be found per tree toward the end of the first-brood period. If the fruits are nearly grown when this injury occurs, they may mature early and drop before harvest. Leaves near the tips of infested spurs may turn black and remain on the spur (Figs. 1, 4 and 5). Occasionally a new shoot near the tip of the spur will wilt and turn black.

When the larvae are full grown, most of them leave the burrows in the spurs and cocoon in the usual manner. Occasionally a first-brood larva may cocoon within the burrow in the spur. After the larvae have left the burrows a callous growth forms, which may fill the burrows completely.

The spur-burrowing habit of codling-moth larvae has an important bearing on codling-moth control. The fact that the lavae enter the spurs through fruit scars which may have little or no spray protection makes it difficult to prevent an increase in second-brood larvae. It is not known whether the progeny of moths from first-brood spur-worms will attack only the spurs or also the fruit, however, in either case the fruit will be injured.

CONTROL MEASURES.—No practical control measures have yet been worked out. Owing to the fact that the natural fruit drop during the first-brood period extends over a long time, many scars left by fallen fruits will have no spray covering, or at most only a light coating. The regular cover sprays will not give adequate protection, and it is not practical, both from an economic and a residue-removal standpoint, to increase the number of applications enough to give protection.

SUMMARY.—Spur-burrowing in pear fruit spurs by codling-moth larvae is on the increase in the Rogue River Valley. The fact that young larvae may burrow into fruit spurs with fruit attached, both during the first- and second-brood periods, points to the possible existence of a spur-burrowing strain of codling-moth larvae. There is enough food matter in the spurs to permit the larvae to complete their development and change to adult moths.

This type of injury had been reported for several years prior to 1936, but the identity of the larvae causing such injury was not definitely established until the spring of 1937. Fruit spurs of Bosc and Anjou pear trees with larval injury can be found quite generally throughout the valley in well-sprayed orchards during the growing season. An unsprayed Bosc tree examined three weeks after harvest time had 251 spurs in which larvae had recently worked or were still at work. Black, mummified, young pears adhering to injured spurs in the first-brood period may be mistaken for those killed by fire blight.

Spur-burrowing has been noted chiefly on Bosc and Anjou varieties, however, occasionally an injured Bartlett spur may be found.

The larvae usually enter through a scar left by the separation of a fruit stem from the spur. They may almost completely hollow out the spurs, cutting off the food supply to the fruit and leaves attached to the outer end of the spur. These may turn black and hang until after harvest, or may drop prematurely.

No practical control can be recommended, since the natural fruit drop extends over a long period of time, leaving points of entry which do not have adequate spray protection.—4-4-40.

Bare-rooted trees of hickory, pecan, and walnut and their budwood and scions may enter California from the region quarantined on account of nut-tree insects provided these plants are fumigated according to specifications. They are also subject to treatment upon arrival at destination. This modification of quarantine proclamation No. 12 was made effective July 22, 1940.

A recent revision of California quarantine proclamation No. 16 pertaining to the Colorado potato beetle has for its only change a provision for the release at destination of small uncertified lots or shipments of potato tubers provided they are free from the beetle as well as from soil chunks or plant debris of any kind. The revised proclamation is dated July 22, 1940.

Tests of Rotenone, Anabasine, Nicotine, and Other Insecticides Against the Woolly Apple Aphid and the Apple Aphid

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Increasing interest in rotenone and anabasine as insecticides led to experiments in which rotenone and anabasine sulfate were compared with nicotine sulfate and other aphicides against the woolly apple aphid *Eriosoma lanigerum* (Hausm.) and the apple aphid *Aphis pomi* Deg.[2] These studies were carried on at Wenatchee, Wash., during the period 1931 to 33.

[1] These experiments were conducted cooperatively by the Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, and the Division of Insecticide Investigations, then a part of the Bureau of Chemistry and Soils, but since September 1, 1934, a part of the Bureau of Entomology and Plant Quarantine. C. W. Murray, of the Division of Insecticide Investigations, assisted with some of the tests.

[2] Davidson (1930) and Campbell (1932) showed rotenone to have considerable toxicity to aphids.

Materials.—The rotenone used was a laboratory-prepared sample. The crystals were dissolved in acetone (U.S.P.) and the solution was then added drop by drop and stirred into the proper amount of distilled water. Owing to the tendency of rotenone solutions in acetone to lose stability readily, the mixtures were made up not more than 2 or 3 hours before being used.

The anabasine sulfate used in 1931 and 1932 was a laboratory-prepared sample and contained 40 per cent of alkaloids, of which 16 per cent was anabasine and 24

Table 1.—Mortality of the woolly apple aphid following treatments with various insecticides, September 1931.

Insecticide	Accessory Material Amount to 100 Gallons	Temperature[2]	Number of Aphids	Per Cent Kill
Rotenone				
8 oz. per 100 gal.	—	70°F.	1,339	83.8
		70	1,004	86.8
	activator ½ gal.	55	2,163	69.6
		47	899	59.2
	ammonium caseinate 1 lb.	70	946	85.6
	soap 4 lb.	70	952	93.5
	soap 8 oz.	55	1,570	45.9
		47	972	43.7
5 oz. per 100 gal.	soap 8 oz.	55	1,187	48.4
		47	470	52.1
3 oz. per 100 gal.	activator ½ gal.	47	1,210	53.6
Anabasine sulfate				
1–1,000	activator ½ gal.	55	1,700	99.6
1–1,600	soap 8 oz.	55	1,074	99.2
Nicotine sulfate				
1–1,000	activator ½ gal.	55	1,497	100.0
	soap 4 lb.	70	1,700	99.8
	soap 8 oz.	55	1,180	100.0
1–1,600	soap 8 oz.	55	1,281	99.8
1–3,200	soap 4 oz.	47	1,085	99.5
Oil emulsion[1]				
1 gal. per 100 gal.	soap 2 lb.	47	670	60.4
	soap 1 lb.	47	4,420	54.4
	Activator ½ gal.	47	1,620	22.8
	Soap 2 lb.	55	1,139	41.4
	Distilled water	55	800	9.4

[1] Light medium summer oil emulsion containing 83 per cent of oil with a viscosity of 70 seconds Saybolt and an insulfonated residue of 92 per cent.

[2] Mean average for post-spray period.

per cent methylneonicotine. That used in 1933 was a commercial sample and contained 40 per cent of alkaloids, 29 per cent of which was anabasine and 11 per cent lupinine and other alkaloids. Other insecticides included nicotine sulfate (40 per cent nicotine), oil emulsion, and soap. The soap was a pine tar product.

An activator consisting of a proprietary sulfonated petroleum oil was added to some of the mixtures. The following materials were used as wetting agents: A proprietary alkylated naphthalene sulfonate (Cupples 1938), sodium oleate, ammonium caseinate, and ethyl alcohol (50 per cent), oil emulsion, and soap.

The woolly apple aphid was used in most of the tests, but as its waxy covering (Fig. 1) resists insecticides to some extent the apple aphid was also used as a test insect.

METHODS.—Aphid-infested twigs were put in bottles of water and the bottles placed on paper. Galvanized pans were later used instead of paper as bases for the bottles. Sticky borders encircled the bottles at a 10-inch distance. The bottles and twigs were sprayed outdoors and were left there for a period of 2 or 3 days. At the end of that time mortality counts were taken. The insecticides were applied with a hand sprayer and approximately equivalent amounts of spray were employed for each material.

RESULTS.—The results of these tests are summarized in tables 1, 2, and 3.

DISCUSSION OF RESULTS.—Anabasine sulfate and nicotine sulfate at the lowest

Table 2.—Mortality of the woolly apple aphid following treatments with various insecticides, September and October 1933.

INSECTICIDE	ACCESSORY MATERIAL AMOUNT PER 100 GALLONS	TEMPERATURE[1]	NUMBER OF APHIDS	PER CENT KILL
Rotenone				
1 oz. per 100 gal.	activator ½ gal.	63°F.	1,085	33.6
	alkylated naphthalene sulfonate 2 lb.	63	890	24.1
2 oz. per 100 gal.	activator ½ gal.	63	1,290	48.5
	alkylated naphthalene sulfonate 2 lb.	63	1,000	32.0
3 oz. per 100 gal.	activator ½ gal.	52	2,275	15.8
	alkylated naphthalene sulfonate 4 lb.	52	1,065	82.2
4 oz. per 100 gal.	activator ½ gal.	52	2,285	16.4
	alkylated naphthalene sulfonate 4 lb.	52	1,295	90.3
3 oz. per 100 gal.	activator 1 gal.	50	1,020	44.1
4 oz. per 100 gal.	activator 1 gal.	50	1,195	48.1
6 oz. per 100 gal.	activator ½ gal.	50	1,105	16.7
8 oz. per 100 gal.	activator ½ gal.	50	1,895	20.6
Anabasine sulfate				
1–3,200	alkylated naphthalene sulfonate 2 lb.	63	950	100.0
1–4,800	alkylated naphthalene sulfonate 4 lb.	52	3,695	96.6
1–4,800	activator ½ gal.	50	2,055	93.4
Nicotine sulfate				
1–3,200	alkylated naphthalene sulfonate 2 lb.	63	1,270	100.0
1–4,800	alkylated naphthalene sulfonate 4 lb.	52	810	97.5
	Activator ½ gal. per 100 gal.	63	1,040	19.7
		52	1,395	10.4
		50	1,125	8.4
	Wetting agent 2 lb. per 100 gal.	63	1,720	9.9
	Wetting agent 4 lb. per 100 gal.	52	1,075	58.1
	Distilled water	63	1,105	5.0

[1] Mean average for post-spray period.

Table 3.—Mortality of the apple aphid following treatments with various insecticides.[1]

Insecticide	Accessory Material Amount per 100 gallons	Number of Aphids	Per Cent Kill
Rotenone			
8 oz. per 100 gal.	—	1,015	100.0
	activator ½ gal.	2,355	100.0
	ammonium caseinate 1 lb.	1,670	100.0
	soap 4 lb.	2,477	100.0
3 oz. per 100 gal.	sodium oleate 1 lb.	3,585	99.9
2 oz. per 100 gal.	ditto	1,590	97.5
3 oz. per 100 gal.	ethyl alcohol	2,795	100.0
Anabasine sulfate			
1–1,600	oil emulsion[2] 1 gal.	2,340	100.0
1–1,600	sodium oleate 1 lb.	3,585	99.9
1–3,200	ditto	3,820	99.1
1–4,800	ditto	2,055	95.1
Nicotine sulfate			
1–1,000	activator ½ gal.	2,250	100.0
1–1,000	soap 4 lb.	1,502	100.0
1–1,600	oil emulsion 1 gal.	3,535	98.3
1–1,600	sodium oleate 1 lb.	3,765	99.6
1–3,200	ditto	3,263	99.6
1–4,800	ditto	715	81.8
Oil emulsion	1 gal.	2,055	78.3
	Sodium oleate		
	1 lb. per 100 gal.	3,363	7.5
	½ lb. per 100 gal.	1,460	11.3
	Ethyl alcohol	1,810	58.1

[1] Mean average temperatures during post-spray period ranged from 68 to 75 degrees F.

[2] Medium summer oil emulsion containing 83 per cent of oil with a viscosity of 60 to 65 seconds Saybolt and an unsulfonated residue of 92 per cent.

concentrations tested were about equal in effectiveness against the woolly apple aphid (Table 2). Each gave approximately 97 per cent kill of the woolly aphid at the above concentration when an alkylated naphthalene sulfonate was added as a wetting agent. The wetting agent alone gave a 58 per cent kill. At a concentration somewhere between 1 to 3,200 and 1 to 4,800 of both anabasine sulfate and nicotine sulfate, even with the wetting agent doubled, the mortality of the woolly apple aphid began to fall off from 100 per cent (Table 2). Between the same concentrations, with sodium oleate as a wetter but with the wetter not increased at the 1 to 4,800 concentration, the mortality of the apple aphid also began to fall off from 100 per cent (Table 3).

Rotenone proved rather ineffective against the woolly aphid at concentrations as high as 8 ounces in 100 gallons of water, and when used with the same wetters as were employed with anabasine sulfate and nicotine sulfate and other materials. At the maximum concentration of 8 ounces per 100 gallons, with 4 pounds of soap, a kill of only 93.5 per cent was obtained (Table 1).

In the tests with rotenone the final spray liquid in some instances showed a faint cloudiness, but in no case was there any large quantity of undissolved rotenone crystals, which, as Richardson (1935) pointed out, might invalidate tests with this material.

Against the green apple aphid, however, rotenone gave 100 per cent mortality at a concentration of 3 ounces in 100 gallons, and an approximately complete kill at 2 ounces with sodium oleate (Table 3). Nicotine and anabasine sulfate with accessory agents gave almost complete mortality down to concentrations of 1 to 3,200 and anabasine sulfate gave a 95 per cent kill at a concentration of 1 to 4,800. This species is undoubtedly much more susceptible than the woolly aphid.

Proprietary sulfonated petroleum activator, alkylated naphthalene sulfonate, pine tar soap, light medium oil emulsion, and sodium oleate all proved effective as wetting agents against the woolly aphid. Each possessed a certain lethal value of its own.

Medium summer oil emulsion, as used in codling-moth control, resulted in only

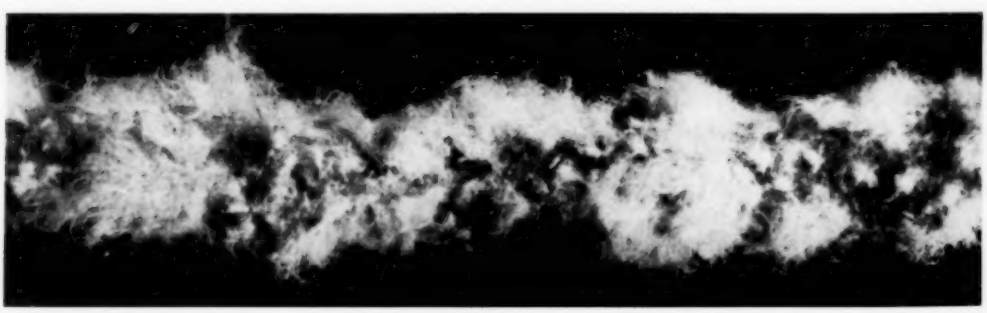

FIG. 1.—Woolly apple aphid on an apple twig, showing the mass of waxy "wool" which covers the insect and tends to prevent penetration of control sprays. ×2½

78.3 per cent mortality of the green aphid (Table 3). Light medium summer oil emulsion with 1 and 2 pounds of soap in 100 gallons gave mortalities of only 54.4 and 60 per cent of the woolly aphid (Table 1).

In tests with 8 ounces of rotenone and 2 quarts of activator (Table 1) and with the activator alone (Table 2) a positive correlation was shown between the temperature prevailing during the post-spray period and the per cent kill obtained.—4-13-40.

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Influence of Road Dust upon Codling Moth Control[1]

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During recent drouth seasons, growers have complained about excessive codling moth injury in areas bordering upon dusty highways and orchard roads. This injury has occurred when the same spray programs gave excellent control in other parts of the orchards.

It seemed possible that the drifting road dust might be responsible for the increased injury, but a review of the literature failed to reveal a single reference to the condition or its cause. A study was therefore begun to determine whether road dust was responsible, and if so, its probable action (Callenbach 1938, 1939).

1937 INVESTIGATIONS.—Preliminary data were obtained in 1937, in cooperation with the Plant Pathology Department, from apple scab spray plots. Two series of plots were available, one composed of McIntosh, the other of Dudley trees. The data for 1937 indicate only the total number of apples injured, no attempt being made to classify the injury.

Figure 1-B represents the arrangement of the Dudley plots, the location of the roads and the geographical orientation. The feathered arrow indicates the direction of the prevailing winds. The plots were surrounded on all sides except the south by the orchard; the south side bordered upon a woods. In general, the orchard roads follow the ridge lines. The part labeled "Orchard Road" was in constant use and during the summer drouth was covered with several inches of dust. The side road, as far as the fork, was used to a considerable extent and was quite dusty, while the two branches beyond the fork were used very little and were overgrown with grass. The topography of the plots was somewhat irregular in contour, with a slight slope to the south and west in the southern section, and to the east in the northern section. There were no steep side hills. The prevailing winds are south to southwest. Plots 11, 12, 13, and 14, therefore, received the most dust.

Table 1 contains the harvest record and shows the number of trees in each plot from which data were taken, the total

Table 1.—Harvest record from Fort Orchard Dudley plots—1937.

PLOT	COUNT TREES	TOTAL FRUITS	NUMBER INJURED	PER CENT INJURED
1	8	877	100	11.4
2	1	771	88	11.4
3	8	1,155	85	7.4
4	8	1,136	61	5.4
5	5	966	19	2.0
6	8	1,056	42	3.9
7	17	1,785	98	5.5
8	15	1,372	65	4.7
9	9	1,056	74	7.0
10	14	1,413	113	8.0
11	4	3,200	509	15.9
12	11	1,171	132	11.3
13	15	1,461	156	10.7
14	11	1,204	196	16.3
15	6	1,081	39	3.6

[1] This paper is published with the approval of the Associate Director of the Wisconsin Agricultural Experiment Station.

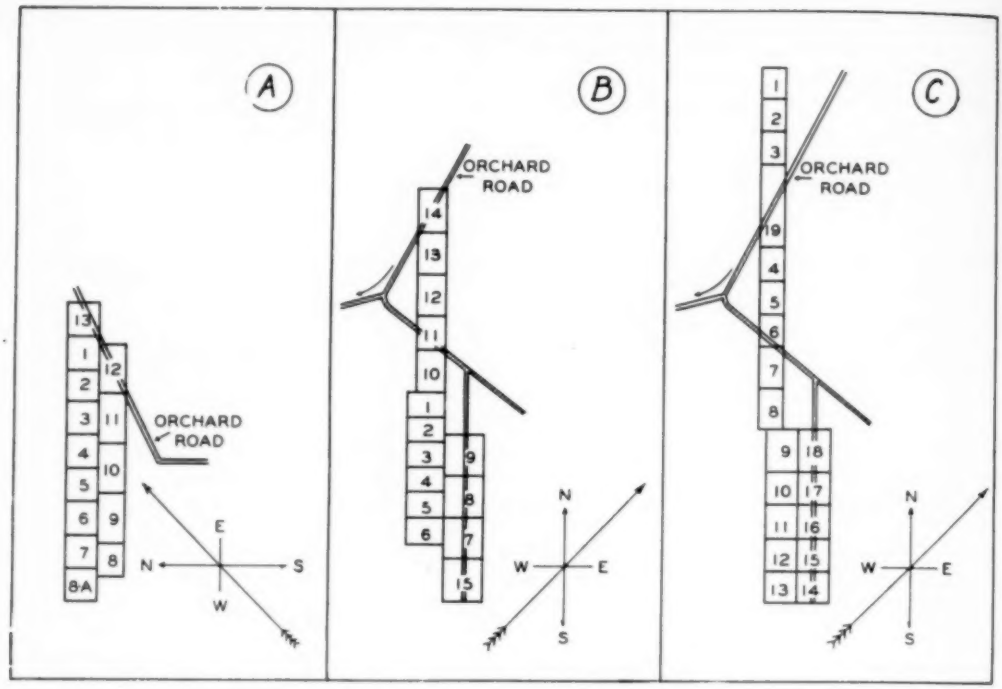

FIG. 1.—Map of experimental plots. A—1937 and 1938 McIntosh plots. B—1937 Dudley plots. C—1938 Dudley plots. Gays Mills, Wisconsin.

number of fruit counted, and the number and per cent injured by codling moths. With the exception of plots 1 and 2, the plots most affected by dust recorded the highest percentage of codling-moth injury. With the exception again of plots 1 and 2, the plots to the south, away from the dusty area, ran consistently lower in the per cent of injury. Plot 2 represented a sample from a single tree, which might influence the results considerably. No explanation suggests itself for the inconsistent results in plot 1.

Table 2.—Harvest record from Bidwell Orchard McIntosh plots—1937.

PLOT	COUNT TREES	TOTAL FRUITS	NUMBER INJURED	PER CENT INJURED
1	15	1,123	191	17.0
2	14	1,046	219	20.9
3	14	790	191	24.2
4	14	949	183	19.3
5(check)	4	835	200	23.9
6	10	711	90	12.6
7	14	738	90	10.8
8	10	887	107	12.1
8A	15	988	121	13.4
9	16	854	152	14.2
10	17	855	168	17.7
11	14	674	205	24.9
12	6	784	186	26.1
13	8	647	158	28.8

Figure 1-A represents the McIntosh plots which were situated about 100 yards to the west of the Dudley plots. These plots extended down a considerable slope to the northwest, the lower edge being approximately 75 feet below the ridge line marked by the road. Except for the north side, the plots are surrounded by the orchard. The eastern half of the north side was bounded by a young cherry orchard, and the western half by woods. The road is the "Orchard Road" mentioned before.

Table 2 presents the harvest data for the plots. Without exception, the plots east of the check plot received more codling-moth injury than those west of the check. All plots east of the check were within the dust range, and the injury was uniformly more severe as the road was approached. Injury was approximately equal in all plots west of the check, out of the dust area.

1938 INVESTIGATIONS.—While the data obtained in 1937 indicated that road dust was the probable cause of greater codling-moth injury in the region of dusty roads,

the topography of the McIntosh plots, might, in part, have accounted for the greater injury in the easter plots. The 1938 investigations were designed to repeat the 1937 program and to supplement it with additional observations, in order to account for the possible influence of the slope and woods.

Figure 1-C and table 3 give the arrangement and data for the 1938 Dudley plots. Because of almost continuous rains during July and August, in comparison with 1937, there was little dust and only trees immediately bordering the road were affected to any extent. The data show that plots immediately adjacent to the roads were the more severely injured, while all other plots were uniformly less injured. Thus, plots 6, 7, and 19 received what little dust there was and showed the greatest injury. Plots 3 and 16 were check plots and indicate uniform infestation throughout the plots.

Table 3.—Harvest record from Fort Orchard Dudley plots—1938.

Plot	Count Trees	Total Fruits	Number Injured	Per Cent Injured
1	8	1,066	47	4.4
2	11	1,187	49	4.1
3(check)	4	3,172	592	18.7
4	10	1,132	91	8.0
5	8	918	84	9.1
6	12	822	178	21.6
7	15	1,097	152	13.8
8	7	1,150	109	9.5
9	9	1,096	74	6.7
10	8	1,011	101	9.9
11	11	1,144	99	8.7
12	10	1,005	58	5.8
13	14	1,125	44	3.9
14	11	1,146	75	6.5
15	7	1,176	79	6.7
16(check)	6	2,733	514	18.8
17	11	1,187	83	7.0
18	10	1,156	73	6.3
19	15	1,205	158	13.1

Figure 1-A and table 4 give the arrangement and data for the 1938 McIntosh plots. Several plots were omitted, but a qualitative analysis of the injury was taken from the plots recorded. No check plot was available in 1938.

The data again show more injury in plots adjacent to the road, and uniformly less injury in the plots away from the road. The data further show that the per cent wormy fruit was greater in plots 12 and 13, the plots most affected by dust.

Table 4.—Harvest record from Bidwell Orchard McIntosh plots—1938.

Plot[1]	Count Trees	Total Fruits	Stings		Worms		Injured Fruit	
			No.	Per Cent	No.	Per Cent	No.	Per Cent
1	7	986	363	36.8	17	1.7	258	26.2
2	5	668	105	15.7	6	.9	86	12.9
3	5	721	101	14.0	5	.7	85	11.8
4	5	783	132	16.9	6	.8	102	13.0
5	4	463	78	16.8	2	.4	60	13.0
7	3	296	93	31.4	1	.3	66	22.3
8	4	511	155	30.3	6	1.2	117	22.9
11	6	1,052	236	22.4	10	1.0	189	18.0
12	5	701	320	45.6	38	5.4	235	35.5
13	7	848	499	58.8	94	11.1	356	42.4

[1] Plots 6, 8A, 9 and 10 omitted.

Plots 7 and 8 were apparently out of line, but the high percentage of injury can be explained by the presence of a large cull pile on the east edge of plot 7, which built up a tremendous local infestation.

In order to obtain data in an area where dust conditions would be the worst, a plot was laid out along the county trunk highway that traverses the orchards. Until it was oiled August 12, this was a non-surfaced dirt and gravel road. The test plot was composed of the Dudley variety and, therefore, the data were in no way influenced by the oil surfacing as this variety had been harvested by that date. The plot was designed so that the rows ran parallel to the highway. Trees in every other row beginning with the row adjacent to the highway were banded.

At harvest, data were taken from windfalls, from fruit around the skirt, from fruit in the tops, and from the bands of each tree in the banded rows. These data were summarized for each row and are presented in table 5. These data again confirm the fact that injury was more severe where the dust effect was greatest.

Additional observations made from similar plots along the highway, which contained Wealthy, Fameuse (Snow), and Northwestern Greening varieties, revealed similar conditions. The conclusion seems valid, therefore, that road dust was the factor which tended to cancel the beneficial effects of the codling-moth cover sprays.

INFLUENCE OF DUST UPON SPRAY DEPOSITIONS.—Dust does not stick readily to the smooth surface of an unsprayed apple. However, after a spray is applied the deposited residue offers a rough surface to which dust sticks readily. As the surface area increases the spray deposits are

cracked and left in patches upon the surface. Thus dust has a tendency to build up into thick layers on the residue deposits, while the unprotected areas remain comparatively free of dust.

To determine the validity of these observations, uninjured fruits were collected and exposed to thorough spray applications, part of them being sprayed with a spray gun and part with a hand sprayer After the spray had thoroughly dried, finely powdered dust from the road was blown over the fruit until they were thoroughly coated. Sections of some of the fruits were then wiped clean and the dust again blown over them. The dust on the original deposit stuck tightly but the dust on the wiped surface could be easily blown or shaken off. By soaking the fruit with a fine atomizer, to simulate the nightly dew, allowing the fruit to dry, then repeatedly blowing dsut over the fruit, heavy dust deposits were built up over the original spray deposit, but the smooth surfaces remained relatively clean.

Observations thus far reported are concerned with the influence of dust upon spray deposits applied before the dust layers had accumulated. Since additional applications are made at later dates, these sprays might be expected to nullify the dust effect. However, experience has shown that application of a spray to a tree heavily coated with dust is impossible unless the gun is opened wide and the tree is drenched. If the ordinary procedure of misting the spray is followed, the fine droplets settling on the dusty fruit act in the same way as a light rain falling on a dusty road or field. The droplets fail to wet the surface, quickly coalesce into larger drops and run off onto the ground. Since the weather, during a drouth period, is usually hot, excessive fruit and foliage injury could be expeted from drenching the tree, and most growers would accept the codling-moth injury in preference to burned fruit and injured trees. The dust effect is, therefore, further extended to prevent the deposition of new deposits.

INFLUENCE OF DUST UPON LARVAL ACTIVITY.—Fruit from a tree severely affected by drifting road dust shows practically all of the injury confined to the dust-free surfaces. The preceding observations have indicated that this is due to a mechanical action, probably in the nature of a barrier, by the dust deposits. A heavy dust deposit would prevent the larvae from contacting poison deposits while moving over the surface of the fruit, and would also prevent entry at a point where the larva might obtain a poisonous dose.

Table 5.—Harvest and band records from Hillside Orchard plots—1938.

Location	Count Trees	Total Fruits	Stings	Worms		Injured Fruit		No. Bands	Cocoons per Band
				No.	Per Cent	No.	Per Cent		
Row 1	4	1,548	740	334	21.6	534	34.5	22	2.4
3	4	1,840	514	233	12.6	501	27.2	17	2.4
5	3	1,278	214	108	8.5	230	18.0	14	2.1
7	4	1,466	184	106	7.2	223	15.2	12	2.1
9	3	1,096	190	87	7.9	194	17.7	13	1.5

Gilmer (1933) made extensive observations of the entrance of codling-moth larvae into the fruit, with special reference to the ingestion of poison. He reported that the larva usually wanders aimlessly over the fruit, then spins a silk mat, after which it begins to chew its way through the skin. He further reported that, during entrance, the larva ingests none of the skin or the pulp immediately under the entrance hole. Most of the poison is accidentally acquired by taking in bits of skin and pulp cut from the fruit while entering. These bits may contain particles of poison from the spray deposits at that point, or the particles which have been collected on the setae and appendages and then rubbed off by movements of the larva during penetration. While the bits of skin and pulp are expelled later, a considerable portion of the foreign material remains in the mouth, and, if it includes a poison, the larva soon dies.

Smith (1929) reported that out of 23 successful entries by test larvae on heavily sprayed fruit, only 1 was through a deposit, 12 were at the edge of the deposits, and 10 between the deposits. He further

pointed out that the young larva spins a light mat of fibers to which it clings while eating its way through the skin of the apple, and that the deposit forms a favorable place of attachment, but entry is made in the spaces between the deposits. An analogous situation exists with dust deposits.

SUMMARY.—Observations indicate that road dust is a detriment to codling-moth control in sprayed orchards, and that codling-moth injury is uniformly greater the more severe the dust condition. Where dust is deposited in extremely heavy layers, the entire benefit of spray applications may be lost.

The probable explanation of the dust effect is in the nature of a mechanical action which may be summarized as follows: Spray deposits tend to dry in patches, and these patches are in turn broken up into smaller patches by surface increase of the fruit. Dust sticks readily to these deposit areas but not to any extent to smooth unprotected parts of the fruit. Because of the mechanical barrier raised by heavy dust deposits, the larvae are compelled to attempt entry through the unprotected portions of the fruit, and hence are unharmed by the original spray deposits. Because of the same barrier, the larvae are prevented from contacting the particles of poison while crawling over the surface prior to entry. Dusty fruit is difficult to spray because the dust causes the drops to coalesce and run off without wetting the surface. Therefore, later applications are also rendered ineffective because of the impossibility of applying them properly.—4-22-40.

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Effect of Pyrethrum and Derris on the Black Blister Beetle

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During the season of 1937 the black blister beetle, *Epicauta pennsylvanica* (Deg.), invaded a field of china asters being used in experiments with aster yellows. The beetles occurred in such large numbers that it became necessary to inaugurate control measures to save the flower crop for the purpose intended. The beetles devoured the inner flower parts as soon as the buds showed color so a quick kill was essential. Contact sprays were therefore selected rather than stomach poisons, such a sodium fluosilicate or calcium arsenate, which are generally used for the control of blister beetles feeding on foliage.

In a preliminary field test a spray containing pyrethrum extract diluted to give a total pyrethrin content of 1:10,000,* derris powder diluted to give a rotenone content of 1:18,000, and a spreader paralyzed the adults in from 30 seconds to 2 minutes, but 70 per cent of them recovered at the end of 24 hours.

In further spray tests in the field pyrethrum extract and derris powder were used at various concentrations, both alone and in combination with each other. A commercial extract of derris root containing pine oils, ethylene dichloride, and other ingredients was also combined with pyrethrum. The different spray combinations are given in table 1. The derris powder contained 4.7 per cent of rotenone and 18.6 per cent of total extractives. The pyrethrum sprays having pyrethrin contents of 1:11,000 and 1:22,000 were made from a commercial product containing 18 grams of pyrethrum extract (total pyrethrin content 1.8 grams) per 100 cubic centimeters and all other pyrethrum sprays were made from an alcoholic pyrethrum extract (total pyrethrin content 2 grams per 100 cubic centimeters). A

* All concentrations of pyrethrum and rotenone are given in parts by weight.

commercial spreader containing alkylphenylbenzenesulfonic acid was added at the rate of 2 grams per gallon to all sprays except the 1:11,000 and 1:22,000 pyrethrins.

The tests were made on different days early in September at temperatures ranging between 75 and 82 degrees F. The insecticides were applied with a knapsack sprayer at 40 pounds' pressure. All beetles were thoroughly wetted while on the plants and again after they dropped to the ground. Paralyzed beetles were picked from the ground and held for 24 hours in screen-covered petri dishes. Beetles that recovered from the paralytic shock were transferred to screen cages and fed fresh aster flowers, and the mortality was recorded on the fourth day.

The several spray combinations varied considerably in paralytic action. When the pyrethrin content was 1:5,000 almost immediate paralysis occurred but when it was 1:22,000 from 2 to 5 minutes were required. Sprays containing only derris powder showed no paralytic effect.

Table 1 shows the percentage of beetles recovering from paralysis following the different treatments and the percentage of those beetles that finally died.

Table 1.—Effectiveness against the black blister beetle of various pyrethrum and derris sprays in field tests on asters, Beltsville, Md., 1937.

Spray Material	Number of Tests	Number of Insects	Per Cent Recovering in 24 Hours	Per Cent Dead After 4 Days
Pyrethrum extract				
Pyrethrins 1: 5,000	2	189	22.2	73.5
Pyrethrins 1:10,000	1	61	49.2	68.8
Pyrethrins 1:11,000	3	245	54.3	62.8
Pyrethrins 1:22,000	1	75	40.0	42.6
Pyrethrum extract and derris powder				
Pyrethrins 1: 5,000, rotenone 1: 4,000	3	215	3.7	91.6
Pyrethrins 1:10,000, rotenone 1:18,000	4	198	27.3	73.2
Pyrethrum extract and derris extract				
Pyrethrins 1: 5,000, rotenone 1:18,000	3	258	20.5	84.9
Pyrethrins 1:10,000, rotenone 1:18,000	1	118	22.0	61.0
Derris powder, rotenone 1:4,000	1	72	97.2	11.1
Check	3	197	100.0	2.5

Although more of the beetles recovered from paralysis after having been sprayed with pyrethrins 1:10,000 than with pyrethrins 1:5,000, the final mortality was approximately the same. The addition of derris increased the killing effect of the 1:5,000 spray but not of the 1:10,000 spray.

Pyrethrum extract sprays containing pyrethrins 1:11,000 and 1:22,000 gave comparatively low kills.

A test with derris extract to give a rotenone content of 1:4,000, for comparison with the derris powder spray at the same concentration was not made becasue of the excessive gummy residue produced when the extract was mixed with water.

That the black blister beetle is highly resistant to pyrethrum is indicated by the fact that sprays having pyrethrin contents of 1:10,000 and 1:22,000 killed all adults of the cucumber beetles *Diabrotica duodecimpunctata* (F.) and *D. vittata* (F.), the tarnished plant bug, *Lygus pratensis oblineatus* (Say), and the garden flea hopper, *Halticus citri* (Ashm.), which occurred on asters at the same time.

During the active season adults of the black blister beetle move into the aster plantings daily, where they feed voraciously for a few days and then apparently return to their breeding grounds. To protect plants from such a rapidly changing population, repeated applications of insecticides become necessary. Since incomplete kills were obtained with even the most concentrated sprays tested, it appeared desirable from the standpoint of field control to determine the effect of a second application of the same spray on insects that had recovered from paralysis.

In 1938 laboratory tests were conducted in which one and two applications of pyrethrum extract sprays were made on separate lots of field-collected beetles. The procedure used was a modification of the turntable method for testing fly sprays (Campbell & Sullivan 1938). The test cages consisted of screen-covered petri dishes 145 millimeters in diameter and 52 millimeters deep. The use of water as the diluent made it necessary to remove the slide separating the spray chamber from the cage holder. The beetles, were sprayed directly with 10 cubic centimeter aliquots of the pyrethrin test solution. The test room was maintained at a constant temperature of 28 ± 0.5 degrees C.

After being exposed for 5 minutes, the beetles were removed to observation cages and provided with water and aster flowers. Mortality counts were made at the end of 24, 48, and 72 hours. At the first examination the beetles were classed as recovered, moribund, or dead. After it was found that the moribund beetles fi-

nally died, they were recorded as dead on the first count, and the later counts were then omitted from the records.

The sprays used were aqueous dilutions of a pyrethrum concentrate containing 5 milligrams of pyrethrins (pyrethrin I, 45.2 per cent and pyrethrin II, 54.8 per cent) per milliliter of ethyl alcohol. The pyrethrum concentrate was prepared by H. L. Haller, of the Division of Insecticide Investigations, from a pyrethrum sample which analyzed 23.8 per cent of pyrethrin I and 28.9 per cent of pyrethrin II, the remainder being of unknown composition. Total pyrethrin concentrations of these sprays were 1:8,000 and 1:16,000. Sodium lauryl sulfate (1:3,000) was added to each spray as a spreading agent.

Four lots of field-collected beetles were tested in the following manner. Each lot was placed in a large milk pan and random samples were taken. A sample of beetles was sprayed and the insects that survived were resprayed on the following day. On that day another sample from the same collection was sprayed for the first time. The results of these tests are summarized in table 2.

In tests with the 1:8,000 pyrethrin spray, 77 per cent of the beetles were killed by the first application and 44 per cent of the surviving beetles by the second application, resulting in a final mortality of 87 per cent. In parallel tests with the 1:16,000 pyrethrin spray, 57 per cent of the insects were killed by the first application and 28 per cent of the survivors by the second, resulting in a final kill of 69 per cent.

The lower mortality from the second application was believed to be due to greater resistance of the beetles surviving the first application. In reviewing the manuscript H. H. Richardson has also pointed out that any mortality among the survivors of the first spray following the second application of the same spray indicated that the beetles had not fully recovered from the first spray but had weakened and become more susceptible.

In two of the replicates a single application resulted in comparable mortalities for each pyrethrin spray, 75 and 77 per cent for the 1:8,000 concentration and 53 and 57 per cent for the 1:16,000 concentration. Although the results for the same concentration show little variation, those for the two concentrations are significantly different (77 ± 5.8 and 57 ± 5.3).

Mortalities were on an average 11 per cent higher for beetles sprayed on the first day than for those sprayed for the first time on the second day. This slight increase in resistance of beetles sprayed on the second day may have been due to the longer period spent under favorable laboratory conditions, where both food and water were provided.

Examination of all recovered, moribund, and dead adults in two series of tests showed that males and females responded similarly.

Table 2.—Average mortality of the black blister beetle at the end of a 24-hour period following one and two applications of sprays by the turntable method, Beltsville, Md., 1938.

Spray Material	Time of Spraying	Total Number of Insects Used (Four Replicates)	Mortality Per Cent
Pyrethrum concentrate			
Pyrethrins 1:8,000	First day	197	77 ± 5.8*
	Resprayed second day	44	44 ± 3.3
	Second day only	150	66 ± 3.5
Pyrethrins 1:16,000	First day	193	57 ± 5.3
	Resprayed second day	88	28 ± 2.7
	Second day only	125	46 ± 3.9
Sodium lauryl sulfate 1:3,000	Sprayed on first day	151	8

* Standard error of mean.

The recovered beetles seemed from external appearances to be only temporarily affected by the pyrethrum. The moribund adults that finally died were evidently affected differently than were the recovered or the dead beetles. A histological comparison of the beetles falling into these three groups might add to our present knowledge of the effect of pyrethrum on insects (Hartzell 1934).

From a practical standpoint it appears than when repeated sprayings of pyrethrum extracts with or without derris are made on aster incomplete but satisfactory kills of adult black beetles can be obtained. It is felt, however, that the results are preliminary in nature owing to the relatively small number of insects that were available for testing. A more extensive study of this problem is to be undertaken in the future.

SUMMARY.—In field tests on china asters sprays containing pyrethrum extracts (pyrethrins 1:10,000 and 1:22,000) killed 68.8 and 42.6 per cent of the black blister beetle, *Epicauta pennsylvanica* Deg., as

compared with complete mortalities of cucumber beetles, the tarnished plant bug, and the garden flea hopper, which occurred on the plants at the same time. Derris powder and derris extract (rotenone 1:18,000) when added to sprays containing pyrethrins 1:10,000 did not increase the killing effect but when added to sprays containing pyrethrins 1:5,000 a higher kill was obtained. The most effective spray was one containing pyrethrum extract (pyrethrins 1:5,000) and derris powder (rotenone 1:4,000), which killed 91.6 per cent of the beetles. The derris powder when used alone killed 11.1 per cent of the beetles. A spreader containing alkylphenylbenzenesulfonic acid was added at the rate of 2 grams per gallon.

Because repeated applications of spray were necessary to protect asters from a rapidly changing population of blister beetles, it seemed desirable to determine the effect of a second spraying on the insects surviving the first treatment. By a modified turntable method alcoholic pyrethrum extract diluted to give pyrethrin contents of 1:8,000 and 1:16,000 in water was tested on field-collected beetles. Sodium lauryl sulfate (1:3,000) was added as a spreader.

The more concentrated spray killed 77 per cent of the beetles on the first application and only 44 per cent of the survivors on the second, giving a final kill of 87 per cent. The less concentrated spray killed 57 per cent of the beetles on the first application and only 28 per cent of the survivors on the second, giving a final kill of 69 per cent. These tests indicated that the weaker beetles are killed by the first application. The more resistant survivors seemed completely recovered from the first application, but since some of them succumbed to a second treatment the first spray apparently had a residual effect. Moribund adults finally died. No sexual differences in susceptibility or resistance occurred among the beetles.—4-29-40.

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SCIENTIFIC NOTES

Eufallia unicostata, a Fungus Eating Beetle New to Puerto Rico

During November, 1939, large numbers of psocids were noted on the walls of some of the laboratories in this Institution. Later, an examination of the specimens also disclosed the presence of numerous small beetles. These were identified by W. S. Fisher of the United States National Museum as *Eufallia unicostata* (Belon), family Lathridiidae, a group heretofore unrecorded from Puerto Rico.

Further study demonstrated that both the psocids and beetles were found only in rooms painted with casein wash paint. Discolored irregularities occurred where these insects were abundant. At the time it was actually believed that they consumed the paint surface.

To supply a request for larvae, a number of beetles were added to a mixture of casein and Purina Dog Chow ration, placed on a filter paper in a petri dish, and moistened. One or two days later the material was covered with a heavy and varied growth of fungi. This, it is believed, was introduced in great part by the adult beetles. Within a few days elliptical, white shining ova, more than half the length of the adult's abdomen, were deposited. Mature larvae were present three weeks later.

Neither adults nor larvae were observed feeding upon particles of casein. However, they avidly consumed fungi, especially the fruiting bodies, which in all probability constitute their principal means of sustenance. After the larvae were collected the culture became dry through neglect. Oviposition ceased, and adults began to die. However, it was noted that psocids which had gained admittance thrived under these conditions.

During the early months of 1940 relatively dry conditions prevailed, and few beetles or psocids were observed. With increased precipitation during May, adult beetles again became numerous. Careful search with a binocular loupe disclosed an egg on the walls only once, while larvae were never seen there. Presumably they seek more sheltered places.

This is probably true for the adults during periods of lower rainfall. At this time the discolored areas on the walls were again given attention. They proved to be fungous growths upon which beetles and psocids fed. Over much of the paint surface fine pitting could be discerned. Whether this resulted from penetration of the paint by fungi, or from activity of the beetles, was not determined.

Summarizing these findings, we find that *Eufallia unicostata* is new to the fauna of Puerto Rico.

It feeds upon fungi which grow in great abundance on casein wash paint.

Due to the discoloration caused by fungi upon walls so surfaced it is believed casein wash paint should not be used in warm regions of high humidity, unless altered to prevent development of fungi.

Eufallia unicostata appears to be easily cultured and may prove to be a useful experimental subject in much the same way as *Drosophila* and *Tribolium*.—7-5-40.

WM. A. HOFFMAN from the *School of Tropical Medicine, San Juan, P.R.*

Natural Dispersion of *Aphelinus mali* (Hald.)

Aphelinus mali (Hald.), the parasite of the woolly apple aphid *Eriosoma lanigerum* (Hausm.), was introduced into the Pacific Northwest by Childs & Gillespie (1932), who imported it from Michigan into the Hood River Valley of Oregon in 1928 and 1929. Before that it was not known to occur in this region. Venables (1931, 1937) introduced the parasite into the Okanagan Valley of British Columbia in 1929 from Ontario, and the writer brought it from Hood River into the Yakima Valley of Washington in 1930 and 1931. Yothers (1934) introduced it into the Wenatchee Valley in 1931, using material obtained from Belleville, Ontario, and from Hood River.

These introductions into a new region have afforded opportunity to observe the natural dispersion of an insect. Childs and Gillespie as well as Yothers report a rather rapid spread of the parasite from points of liberation. Childs and Gillespie mention finding parasitized aphids more than a quarter of a mile from these points the year following introduction. Yothers found that the parasite had spread in all directions 5 to 9 miles from the points of liberation within 3 years. This spread occurred in an area of practically continuous apple orchards. Venables (1937) indicates that the parasite spread rapidly and crossed Okanagan Lake, a distance of 2 miles.

The writer has made three observations which show that *Aphelinus mali* is capable of spreading considerable distances even over country in which there are no apple trees and no woolly aphids.

Along the main highway running south from Wenatchee on the east side of the Columbia River there are a few half-dead apple trees, the remains of an orchard planted about 30 years ago. In 1937 these trees were examined and found to be infested with the woolly aphid, which was parasitized by the *Aphelinus*. These trees are about 3 miles from an isolated apple orchard, which in turn is 5 or 6 miles from the southern edge of the Wenatchee orchard area. Thus within 7 years the *Aphelinus* had spread over about 10 miles of orchards and about 8 or 9 miles of open country in which there is only the single isolated orchard just mentioned.

In 1937 also a single apple tree was noticed along the highway that leads south from the Yakima Valley to the Columbia River through Goldendale, Wash. This tree was near Satus Creek and appeared to be about 20 years old. It is not known how the tree got there, and there is no evidence of other trees or of a habitation there at the present time. Both woolly aphids and *Aphelinus* were found on the tree, although it is at least 10 miles from any apple orchard in the Yakima Valley, the intervening country being mostly hilly desert, and fully 30 miles in a direct line from the original points of liberation at Yakima in 1930 and 1931. Thus in 6 or 7 years the *Aphelinus* spread over 20 miles in which there are apple orchards at intervals and over an additional 10 miles in which there are apparently no apple trees.

In September 1935 the writer sent to B. G. Thompson, of the Oregon Agricultural Experiment Station, about 2,000 parasitized woolly aphids. These were placed in an apple orchard at Monroe, Ore., near Corvallis, and in July 1936 Dr. Thompson reported that the *Aphelinus* had become established in this orchard. In August 1939 the writer found parasitized aphids in a heavily infested apple orchard at Goshen, Ore., which is 25 or 30 miles southeast of Monroe. The intervening area is rather flat farming country with occasional apple trees or small apple orchards. Dr. Thompson advises the writer that so far as he knows no introductions were made in that region other than in the orchard at Monroe. The owner of the orchard at Goshen was concerned about the infestation of woolly aphids and was unaware of the presence of the parasites.

The only possibility of artificial spread would be through the interchange of lug boxes, as both orchards delivered apples to the processing plant of a fruit growers' organization, and boxes brought in from the orchard at Monroe may later have been sent to the orchard at Goshen. This possibility seems rather remote, however, and it is more likely that in this instance a natural migration occurred.

It is remarkable that this insect should have found its way 25 miles in 3 years even though there were apple trees along the way. It is even more remarkable that the insect should have found the isolated tree on Satus Creek, which is almost surrounded by native trees, when there were many miles of open desert between that tree and other apple trees. These observations constitute evidence of the ability of insects to spread naturally wherever favorable conditions exist.—7-8-40.

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Poison Bait for Control of the Strawberry Crown Borer[1,2]

Measures now recommended for crown borer control are cultural in nature. They include use of plants certified as free from crown borer, digging and cleaning of plants for new patches before egg laying commences, destruction of old patches and wild hosts such as cinquefoil, and setting of new patches at a distance of 350 or more yards from a source of infestation.

All these have certain drawbacks. In the case of certification, some states allow patches with a small per cent of borer to pass inspection. Digging and cleaning plants before March is a laborious and often uncertain task. In some areas, heavily infested cinquefoil is abundant on practically every farm and eradication is impractical. Furthermore, setting of new patches at any considerable distance from a source of infestation is often impossible where berries are grown extensively.

In the course of a four year's study of *Tyloderma fragariae* (Riley) the writer has investigated several new methods of control, including the use of barriers and methyl bromide fumigation of plants for setting new patches. A study of poison baits for crown borer control was begun this March.

Tests were made first in the laboratory with overwintering adults confined in jelly glasses. In each case, a berry plant was inserted in damp sand and ten adults placed in each jar. Bait was applied around the crown of the plant. Tests made during the spring months showed that crown borer adults were attracted to fruit-base baits and hardly at all attracted by bran-base baits. Sodium fluosilicate and lead arsenate were both effective poisons.

Further to test the use of poison bait, six, 4½ by 3 foot, wood and metal, crown borer barriers were constructed. These were similar to those described by the writer (Ritcher 1939) except that the metal lip was on the inside. At intervals during the summer, two or more barriers were placed over sections of berry rows in both new and old patches and 50 adults placed inside each barrier. One-half to a teaspoonful of bait was applied to the crown of each plant within one or more barriers.

In addition to the series of barrier tests in progress at Lexington, tests were begun in the Louisville berry-growing area. Bait plots were laid out with interspersed check plots and treated using the delivery apparatus described by Wilcox *et al.* (1934).

In all cases, the bait used consisted of 96.5 per cent dried, chopped, apple refuse coated with 3.5 per cent sodium fluosilicate. Such a bait is sold under the trade name "Go-West" for the control of strawberry root weevil, black vine weevil, and vegetable weevil.

Plots were examined on either the tenth or eleventh day following treatment, the soil being sifted thru screens to recover dead and living adults. In the case of plots 40–11 I, it was not practical to destroy many plants and adults were recovered by inspecting each plant and the soil around it.

Results of bait tests in the field are summarized in Table 1. Numbers 40–11, F, G, H, and J are tests within barriers. Kills for five treated plots ranged from 87.5 to 100 per cent. Numbers 40–11 I and K were tests without barriers, made in patches near Louisville heavily infested with borer. Plots of 40–11 I were each three rows wide and 30 feet long and located in a patch set this spring. Tests number 40–11 K were made in a matted row of a two-year-old patch. Each plot was 15 feet long. The mortalities of from 77.7 to 84.3 per cent, found in four field plots not surrounded by barriers, are considered good because of possible migration and the emergence of adults in progress at the time.

Table 1.—Field tests with "Go-West" bait for the control of strawberry crown borer.

Plot No.	Date Treated	Adults Found	Adults Alive	Per Cent Mortality
40–11 F 1	6/28/40	37	0	100
Check	—	46	43	6.5
40–11 G 1	7/20/40	21	1	95
40–11 G 2	7/20/40	33	2	94
Check	—	32	31	3.1
40–11 H 1	7/20/40	30	0	100
Check	—	27	25	7.4
40–11 I 1	8/2/40	32	5	84.3
Check	—	34	33	2.9
40–11 I 8	8/2/40	27	6	77.7
Check	—	58	52	10.3
40–11 J 1	8/9/40	32	4	87.5
Check	—	40	39	2.5
40–11 K 2	8/12/40	29	6	79.3
Check	—	42	42	0
40–11 K 4	8/12/40	21	4	80.9
Check	—	23	23	0

It is realized that these experiments represent but one season's work and include some applications made at times when bait would not be applied normally. However, the results are so encouraging that they are presented in order that other workers can plan to make bait tests early this coming year at the logical time for treatment.—8-16-40.

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[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2] Early publication of this paper has been secured by payment of cost of printing.

Fumigation Tests in Open Tobacco Warehouses

Cured tobacco is stored in warehouses for long periods in order to obtain a satisfactory degree of fermentation, or aging. These warehouses are given the general designations of open and closed types. The closed warehouse is constructed of brick, concrete, or boards, tightly fitted, with a sufficient number of ventilators along the walls to provide the desired aeration of the tobacco. These buildings lend themselves to temporary sealing without great cost, and experimental work conducted during the past few years has developed an effective method of fumigation for hogsheads and cases of tobacco.

The open type of tobacco warehouse, however, is constructed with corrugated sheet metal walls, concrete or earthen floors, and a composition roof made of tar and gravel. The sections are usually contigu-

ous, with brick firewalls between. Two or more louvers extend along the walls, which give a high degree of aeration and provide conditions of temperature and relative humidity closely approximating the outside air. A typical section of open warehouse is 150 by 103 by 15½ feet, having a total volume of 239,475 cubic feet. A section of this size has a storage capacity of about 1,600,000 pounds of tobacco.

Up to this time the only insect-control measures developed for the tobacco moth, *Ephestia elutella* (Hbn.), and the cigarette beetle, *Lasioderma serricorne* (F.), in open warehouses are insect traps and applications of pyrethrum powder. During September and October 1939 the first tests were made of the effectiveness of sealing and fumigating the open type of warehouse with hydrocyanic acid.

In order to retain an effective concentration of hydrocyanic acid in tobacco warehouses even for a few hours, it is necessary to seal all openings temporarily. These openings include doors, louvers, and small cracks along the walls where pieces of sheet metal are riveted together. In these tests the doors were temporarily sealed with a waterproof reinforced building paper, the louvers with a waterproof canvas

FIG. 1.—Sealing louver openings with gas-tight canvas prior to application of hydrocyanic acid gas in open warehouses, Richmond, Va., 1939.

Table 1.—Mortality of the tobacco moth and the cigarette beetle in open-warehouse fumigation tests with hydrocyanic acid gas, Richmond Va., September and October, 1939.

Ounces of Fumigant per 1,000 Cubic Feet	Temperature, Degrees F.	Stages of the Insect					
		Adults		Larvae		Eggs	
		Number	Per Cent Mortality	Number	Per Cent Mortality	Number	Per Cent Mortality
		Cigarette beetle					
8	82	447	100.0	224	100.0	452	100.0
6	70	425	93.8	298	100.0	495	100.0
6	71	460	83.7	223	77.3	1,756	100.0
Check	74	150	0.0	94	3.2	579	2.6
		Tobacco moth					
8	82	259	100.0	188	100.0	156	100.0
6	70	279	100.0	218	100.0	156	100.0
6	71	262	100.0	144	100.0	512	100.0
Check	74	88	30.7	44	4.6	151	52.9

weighing 9.93 ounces per square yard, and the spaces around the rivets and other openings with a plastic insulating material. The sealing of louvers and the application of the plastic insulation are shown in figure 1. Standard quarter-inch copper pipes and nozzles were installed for the application of the hydrocyanic acid.

Three tests were conducted in the open warehouse, using the fumigant at rates of 8 and 6 ounces per 1,000 cubic feet with an exposure of 24 hours. These concentrations and this exposure were considered sufficient to kill all insects at or near the surface of the tabacco, with no appreciable penetration deeper than about 1 inch into the tobacco. The results were determined by the mortality obtained in test lots of eggs, larvae, and adults of the tobacco moth and the cigarette beetle exposed in the space unoccupied by tobacco in the warehouse during the fumigation. The percentage mortality obtained in test lots of insects is summarized in table 1.

These tests indicate the possibility of the effective fumigation of open warehouses. An 8-ounce dosage of the fumigant provided the most satisfactory results, and it is indicated that dosages of 10 and 12 ounces should be tested in future work.

The cost of the three fumigations was as follows: Labor and materials for piping warehouse $23.95, hydrocyanic acid $255, services of a pest-control operator $270, waterproof canvas for sealing louvers $45.92, plastic insulating material $16.63, and labor for sealing and for opening up of warehouse $135.73. The total cost was $747.23, or about 39 cents per 1,000 pounds of tobacco treated.

It is believed that further experimentation will determine that the cost for labor and materials can be reduced and that the effectiveness of fumigation under these conditions can be increased.—7-6-40.

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Searching for Entomophagous Insects

In discussing the introduction of foreign entomophagous insects Riley (1893) stated "We can hardly expect to succeed in accomplishing much good in this direction without a full knowledge of all the ascertainable facts in the case and a due appreciation of the profounder laws of nature and particularly of the interrelations of organisms." Much good, nevertheless, has resulted from foreign explorations which were conducted more or less empirically.

In practice a few fundamental principles have been followed, such as, first, effective parasites should be sought first in the country where the pest originated (Smith, 1934) and second, all the primary parasites of a pest should be imported and established (Clausen 1936).

The procedure of searching for the parasites of an insect is determined largely by the conditions under which it exists *as a pest*.

If a parasite is to be introduced into artificial environments, that is, unnatural associations of plants or animals, then searching should begin in similar environments in the country of origin. Obviously a species that is effective under such conditions is most likely to be successfully introduced and established in a new habitat.

The *discovery* of both host and parasite also is facilitated by artificial environments. It is a well known fact that insects living under such conditions occur at higher densities and in greater numbers than under primitive circumstances. The plant host of a pest often may be found most readily in artificial plant communities such as botanical gardens, estates and residential areas where there is usually a representative assemblage of local and introduced species.

The influence of artificial environments on the effectiveness of searching varies with the degree of isolation of host and parasite. This fact was recognized by Compere & Smith (1932). They observed that an insect such as the cottony cushion scale, when under control by natural enemies occasionally became very abundant on isolated plants located in places not readily reached by its enemies. "These sporadic isolated infestations usually develop in places out of the usual range of insects, such as dooryard or porch plants or on plants in hotel lobbies in the business or industrial sections of large cities. Such sporadic infestations, however, are only accentuated instances of the natural phenomenon known as "colonial" or "spotted" distribution (Smith 1939). This type of distribution is now recognized as being characteristic of many insect species under effective biological control.

The cottony cushion scale in California, before the introduction of its parasties, uniformly infested large areas of citrus so that they appeared as if they had been in a snow storm (Smith 1933). The effect of the introduction of natural enemies was to change the type of distribution. Now the cottony cushion scale exists in widely separated small groups which wax, wane and disappear, to be replaced by new groups elsewhere. This fact is in accord with the theoretical studies of Nicholson & Bailey (1935) on the interaction of pest and parasite. They postulate that ultimately the pest population may split into numerous widely separated groups of individuals which fluctuate in density independently of one another; that these groups of hosts may be exterminated by the parasites but that meanwhile some host individuals will have migrated and established new groups or infestations.

Compere (1936) states that his best finds have been made by "sidewalk exploring." On a mulberry tree in the center of the industrial district of Sydney he found an effective parasite of the citrophilus mealybug. On potted ferns in the open air patio of the American Embassy in Brazil he found an effective parasite of the long-tailed mealybug. All the black scale parasites established in California as a result of his trip to Africa in 1937 were found in the dooryards of cities. Parasitized black scales were found on fig roots covered with refuse dumped from a window.

While in Australia for the purpose of searching for the citricola scale, the writer found an important parasite of the long-tailed mealybug in burlap bands on dooryard pear trees. In this artificial environment more specimens were obtained in one day than could have been found in months or years of search in primitive areas. The search for citricola scale, beginning in the botanical gardens and city dooryards and ending in the primitive bush "out back" was unsuccessful.

It has been demonstrated that in general the search for parasites should begin in artificial environments, particularly if the original host plant of the pest is unknown. The searching of primitive areas usually is the last resort.—4-15-40.

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Parasites of the Pistol Case-bearer[1]

The pistol case-bearer, *Coleophora malivorella* Riley, first became a major pest of the apple industry of the Shenandoah Valley about 1927. Since that time it has gradually increased in importance. Num-

[1] Published with the approval of the Director of the West Virginia Agr. Expt. Station as Scientific Paper No. 243.

merous severe outbreaks have occurred in widely scattered orchards throughout the entire fruit belt. At time of the first outbreak an effective spray treatment was developed (Gould 1931). The treatment consisted of a summer application of nicotine and oil applied immediately after hatching was completed. While such a treatment is usually very effective, under commercial conditions the results have not always been entirely satisfactory. This is due to lack of thorough timely application and not to ineffectiveness of the materials. The treatment is expensive and as a result the tendency is toward lighter spray applications. Due to the habit of the newly hatched larvae of feeding mainly on the under surface of the leaves, effective application is very difficult.

Later work indicated that summer oil is completely effective when used as an ovicide (Gould 1936). Practically all the eggs are normally laid on the upper surface of the leaves which makes effective application less difficult. However, the difficulty of such a treatment lies in the very brief period in which it is effective. It must be applied before the eggs have hatched and not too long before they have all been laid. The incubation period for the eggs is approximately seven days, therefore, it is essential that the spray be very accurately timed and applied within a period of usually not more than two or three days.

Several other summer treatments have proven to be fairly effective. Most of them are expensive and frequently under commercial conditions it is difficult to obtain effective application. Obviously the time to obtain effective coverage is during the dormant period. At that time the case-bearers are freely exposed so that almost complete coverage can be obtained. During the past ten years extensive tests have been made to develop a satisfactory dormant treatment. Some very good treatments have been developed and will be described more fully in a later paper.

From the standpoint of biological control, few insects present a more interesting problem than the case-bearer. This is due to the fact that a single generation is exposed to parasite attack for a period of more than eleven months. The larvae in all stages of development are freely accessible to parasite attack. The proctective cases also afford excellent protection for the overwintering parasites. As a result the case-bearer is attacked by an almost unlimited number of parasites which normally keep it well under control. Careful observations have been made in abandoned and poorly tended orchards where dense case-bearer populations have been reduced to negligible importance in less than two years by parasites and other natural factors. Hyperparasites and sprays destructive to parasites may materially affect case-bearer population build up.

In connection with the control work conducted during recent years systematic collections of parasites have been made. Some forty species of parasites have been reared from the case-bearer. More detailed rearing records will undoubtedly reveal many more species. The limited number of individuals of certain species recovered indicates that their parasitism of the case-bearer may have been purely accidental. Several of the species recovered may be secondary parasites.

The parasites were identified by C. F. W. Muesebeck, Alan Stone, D. G. Hall, R. A. Cushman, A. B. Gahan and J. M. Aldrich of the Division of Insect Identification of the U. S. Department of Agriculture.

The following parasites[2] have been reared from case-bearers collected in orchards in Jefferson and Berkeley counties with the exceptions noted.

Through the courtesy of Dr. W. S. Hough and R. F. Hatcher of the Winchester Field Laboratory, Winchester, Virginia, five additional species, reared at that station, have been included.

PISTOL CASE-BEARER PARASITES

Anachaetopsis tortricis (Coq.)
Angitia sp.
Bassus coleophorae Rohw.
Bassus n. sp.
Catolaccus aeneoviridis Gir.
Cirrospilus flavicinctus Riley
Coleopisthia (*Trineptis*) *hemerocampae* Gir.
Doryctinae n.g. and n. sp. (May be a new species of *Rhoptrocentrus*)
Elasmus setosiscutellatus Cwfd.
**Epiurus indigator* (Cress.)
Epiurus sp. (probably *indigator*) Cress.
**Epulmus inimicus*
Eulophus magnisulcatus Gir.
**Eupelmus allynii* (French)
**Eupelmus cyaniceps* var. *amicus* Gir.
**Eurydinota lividicorpus* Gir.
Eurytoma sp. (very close to *Phoebus* Gir.)
Goniozus hortorum Brues
Habrocytue sp. Nov. (possibly *phycidis*) Ashm.
Habrocytue thyridopterigis Howard
**Habrocytus piercei* Cwfd.
Hemiteles gracilariae Ashm.
**Hemiteles tenellus* (Say)
Hockeria sp. (probably new)
Horismenus microgaster (Ashm.)
Hypopteromalus inimicus Mues.
**Hypopteromalus tabaccum* Fitch
Hyposoter annulipes (Cress.)
‡*Itoplectis conquisitor*, Say.
Macrocentrus instabilis Mues.
Macrocentrus n. sp.
Meteorus vulgaris Cress
**Microbracon gelechiae* (Ashm.)
**Microbracon pygmaeus* (Prov.)
‡*Microdontomerus anthonomi*, Cwfd.
Monodontomerus? n. sp.
Opius sp.
Rhegmoclema atrata (Say)
Rhoptrocentrus sp.
Spilochalcis albifrons (Walsh)
Spilochalcis torvina (Cress)
‡*Swammerdamella brevicornis*, Meig.
Sympiesis argenticoxa Gir.
**Sympiesis* n. sp.
Tetrastichus sp.

Egg parasites

‡*Anagrus epos* Gir
Trichogramma minuta Riley
‡*Zagrammosoma* sp.

—4-18-40.

EDWIN GOULD and G. H. GEISSLER.[3]

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* Designates the more abundant species reared in 1939.
‡ Contributed through the courtesy of W. S. Hough.
[3] Cooperator, representing the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Observations on Life History of *Aelous mellillus**

The wireworm, *Aeolus mellillus* Say, is of considerable economic importance because of its attack on tobacco, wheat, corn, and other crops. It was mentioned by Comstock (1888) as being present in New York State in numbers and again by Comstock & Slingerland (1891) in their bulletin on wireworms and their control. Webster (1889) stated the worms were abundant and destructive to young wheat in Indiana. Forbes (1892) in his report on corn pests said he had found this wireworm in corn fields in Illinois as early as 1882. More recently, Stirrett (1936) says records of damage to cultivated crops are very recent in southern Ontario, the first being in 1930 when the worms were found injuring tobacco. This wireworm has been a pest for many years on tobacco in Kentucky and a recent article (Jewett 1940) includes records of its injury to that crop.

The life history of this wireworm is still imperfectly known. Comstock & Slingerland obtained adults by placing larvae in breeding cages, but they were not able to state whether adults emerged soon after transformation or hibernated in their pupal cells. Forbes found adults hibernating under different kinds of litter in the field and concluded adults did not hibernate in the pupal cells. From collections of larvae separated as to sizes, he concluded that two years were required for their development. Bryson (1930) and Stirrett (1936) report a life cycle of one year. The life cycle is one year in Kentucky.

The most interesting finding in connection with the life history studies of this beetle is that no males have been found in some territories where this beetle is abundant. In Canada, according to Stirrett, thousands of females have been collected but no males, and presumably the species there is parthenogenetic. He reports failure of preliminary attempts, however, to secure eggs from females brought into the laboratory. The statement is also made that Kansas is the nearest location from which males have been collected. In central Kentucky no males have been collected and none have been found among many adults reared from larvae collected at different times during the year. This is in contrast to the fact that males of *Conoderes auritus* (Hbst.), *C. lividus* (DeG.), and *C. bellus* Say are abundant.

Several attempts to secure eggs from adults reared from larvae and from adults collected in the field failed, although adults often lived several weeks in confinement. This spring, five adults reared from larvae collected in April, laid 91 eggs from May 29 to June 14. The genitalia of the five adults were then removed and examined and all were found to be females. The eggs began hatching June 12 and the range in incubation periods for 45 eggs that hatched to June 17 was 9 to 15 days. The laying of eggs by the virgin females and the fact that eggs hatched show that *Aeolus mellillus* is parthenogenetic. The fact that this species is parthenogenetic probably accounts for the finding of larvae of varying sizes at the same time in the soil. According to Dick (1937) normal parthenogenesis is rare among the Coleoptera, and apparently almost confined to Curculionids.—6-20-40.

H. H. JEWETT, *Kentucky Agricultural Experiment Station.*

* The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

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Effect of Paradichlorobenzene on the Feeding of the Black Carpet Beetle

In connection with the use of paradichlorobenzene as a fumigant against clothes moths and carpet beetles, the effect of low concentrations of the vapor in inhibiting the feeding of these insects has not been generally recognized but is of considerable importance. The fumigant is often used under adverse conditions, where it is difficult to obtain a high concentration of the vapor, or where the concentration fluctuates from time to time. It is in these situations that a low concentration of the gas protects fabrics from damage until a lethal concentration is reached.

The present studies demonstrate the effect of paradichlorobenzene on the feeding of larvae of the black carpet beetle *Attagenus piceus* Oliv. The fumigant is believed to have an anaesthetic effect, which has previously been noted by Jewson & Tattersfield (1922) on mites and by Lehman (1930) on the confused flour beetle, *Tribolium confusum* Jacq. Duv.

Approximately half-grown larvae of *Attagenus piceus* taken at random from a large population were fumigated under conditions simulating those in the ordinary clothes closet. The tests were made in 130 cubic foot closets placed side by side in the laboratory. The closets were constructed of wallboard and left unpainted, and the door cracks were sealed with felt weatherstripping. The paradichlorobenzene crystals were put in muslin bags suspended near the tops of the closets. The larvae were placed on wool and camel's hair cloth in cages (Colman 1932), 50 larvae to a cage and 3 cages to a closet. The cages were suspended 1 foot below the paradichlorobenzene. The paradichlorobenzene and the cloth were each weighed at weekly intervals to determine the amount of fumigant that evaporated and the amount of food that was consumed. No paradichlorobenzene was added to make up for evaporation. The necessary corrections were made in the weight of the cloth for changes in moisture content.

The results of these tests are shown in table 1.

Low concentrations of paradichlorobenzene vapor caused a retardation and finally a cessation of larval feeding. Larvae stopped feeding for periods of 4 to 6 weeks, depending upon the concentration of the

Table 1.—Effect of paradichlorobenzene on *Attagenus piceus* larvae in closets.

Week No.	Temperature Range, Degrees F.	Fumigant Evaporated, Grams	Food Consumed, Milligrams		
			Cage 1	Cage 2	Cage 3
Closet No. 1, 100 grams of fumigant					
1	61–77	29	3	2	8
2	56–77	25	0	0	0
3	63–80	16	0	0	0
4	63–83	15	0	0	0
5	69–84	14	0	0	0
6	62–85	1	18	24	21
7	67–83	0	15	29	14
8	68–82	0	18	21	20
No. larvae alive at end of test			45	41	47
Closet No. 2, 200 grams of fumigant					
1	61–77	48	4	4	2
2	56–77	42	0	0	0
3	63–80	28	0	0	0
4	63–83	24	0	0	0
5	69–84	33	0	0	0
6	62–85	17	0	0	0
7	67–83	8	0	0	0
8	68–82	0	27	12	12
No. larvae alive at end of test			41	27	27
Closet No. 3, No fumigant, Check					
1	61–77	—	27	30	26
2	56–77	—	14	8	12
3	63–80	—	11	10	16
4	63–83	—	18	21	20
5	69–84	—	1	8	14
6	62–85	—	9	6	17
7	67–83	—	4	8	16
8	68–82	—	5	9	21
No. larvae alive at end of test			49	49	49

fumigant, but large proportions of them remained alive at the end of these periods and resumed normal feeding. This resumption of activity before death occurred, due to the dissipation of the paradichlorobenzene vapors, is an important consideration in the use of paradichlorobenzene in the control of carpet beetles.—6-25-40.

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Effect of Methyl Bromide on Apple Maggots in Apples

Phillips *et al.* (1938) have indicated that eggs and larvae of the apple maggot, *Rhagoletis pomonella* (Walsh) may be killed by exposing the fruit to methyl bromide gas. In some of their tests injury to the fruit was observed, and they suggested that the danger of injury might prove to be a serious obstacle to the use of the treatment. In a more recent note Phillips & Monro (1939) were more optimistic concerning the dangers of injury. Additional evidence on this subject is presented herein. The primary objective of these preliminary studies was to determine the effect of the gas on the insect, especially to arrive at some approximation of the minimum effective dosage and exposure period.

Bushel lots of picked apples and half-bushel lots of windfall fruit were fumigated with 1, 2, and 4 pounds of methyl bromide per 1,000 cubic feet of space for 1, 2, and 4 hours, which represented, exclusive of the controls, nine separate treatments. The apple variety used was Wealthy. The object of using both picked and dropped fruit was to test the effects of the gas on two different age groups of the pest. At the time of fumigation the picked fruit probably contained first- and second-instar larvae almost exclusively, except perhaps for a few eggs. Second- and third-instar larvae predominated in the dropped fruit.

The fumigation was done from August 23 to 25, 1939, at the Moorestown, N. J., laboratory of the Bureau of Entomology and Plant Quarantine. The fumigation chamber used had a capacity of 1,000 cubic feet. Conditions in the chamber were as follows: Normal atmospheric pressure was maintained, the temperature ranged between 90 and 95 degrees F., and the relative humidity ranged between 58 and 75 per cent. Following fumigation the fruit was transported to Geneva, N. Y., where each lot was placed in larval-rearing equipment and held at outdoor temperatures, to obtain a record of the number of larvae that survived treatment. Larval emergence in the controls continued over a period of 50 days.

On an average 2.79 larvae emerged per fruit in the picked-fruit series and 3.00 larvae in the dropped-fruit series. All treatments gave complete kills except that with 1 pound of methyl bromide for 1 hour. The control efficiency for that treatment was 91.2 per cent for the picked fruit and 91.9 per cent for the dropped fruit. Definite injury was observed in the sample held at the 2-pound dosage for 4 hours, and in all fruit subject to 4-pound dosages except the picked-fruit sample exposed for 1 hour. In the 4-pound, 4-hour lot the fruit appeared as though it had been scalded. In other lots the injuries occurred in the form of spots, often centering around bruises.

The information gained on the effects of the chemical on the fruit is considered only indicative.—7-10-40.

P. J. CHAPMAN, *New York State Agricultural Experiment Station and U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

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Attractiveness to the Japanese Beetle of Mixtures of Commercial Geraniol and Eugenol

Since 1927 (Richmond 1927; Van Leeuwen & Metzger 1930; Richmond 1931; Metzger 1932, 1934, 1936) a bait composed of 10 parts by volume of commercial geraniol and 1 part of U. S. P. eugenol has been considered to be the most attractive to the Japanese beetle *Popillia japonica* Newman. In 1939, with the development of a more accurate method of evaluating the effectiveness of attractants in the field, a further study was made of the attractiveness of different baits. Among the materials tested were different mixtures of geraniol and eugenol. Commercial geraniol and U. S. P. eugenol were used in these experiments, and were of the same lot as the materials employed in the Federal trapping program during the summer of 1939.

Each bait was placed in five traps. The traps were arranged, 25 feet apart, in latin squares containing 25 traps each, of which 20 traps contained four of the test baits and 5 traps the standard bait, containing 10 parts of geraniol and 1 of eugenol. The size of each experimental square was limited to 25 traps because experience has shown that the variance due to position tends to become disproportionally large as the number of units in the square is increased. It was not possible to include all the geraniol-eugenol mixtures in one square, but as the standard occurred in each square it was possible to correct for the differences in the level of the populations and compare the effectiveness of baits in different squares.

The test baits were not changed during the six weeks the traps were in the field, but the standard bait was renewed at weekly intervals. The beetles were collected from the traps three times weekly, except for a short period at the height of the season when it was necessary to make the collections more frequently. The number of beetles taken in the traps with each test bait and the standard was determined at the end of each week and at the end of the season. The total number of beetles taken by traps baited with each test material and the standard bait, and the relative number taken by each test bait as compared with the standard, are given in table 1.

When first placed in the field, geraniol, eugenol, and the 10:1 geraniol-eugenol mixture were of the same order of attractiveness to the beetles. The 10:2, 10:4, and 10:8 mixtures were definitely more attractive. After the first week the attractiveness of geraniol decreased progressively, but the attractiveness of eugenol and the mixture did not change significantly during the season.

On a seasonal basis, when compared with the standard, geraniol was definitely less attractive, and eugenol and the 10:1 geraniol-eugenol mixture were of about the same order of attractiveness. It was also apparent that the attractiveness increased progressively with the increment in the amount of eugenol, and that the 10:2, 10:4, and 10:8 mixtures were much more attractive than either of the components alone.

It is evident that the attractiveness of the present 10:1 geraniol-eugenol bait can be increased by adding more eugenol. However, in 1939 commercial geraniol was obtained in large quantities for 32.4 cents per pound and U.S.P. eugenol cost $1.12 per pound. The results indicate that the substitution of the 10:8 mixture for the 10:1 mixture now used would increase the attractiveness of the bait 70 per cent, but the cost of the bait would be increased from 39.6 cents to 67.8 cents per pound—an increase of about 71 per cent. This is a problem of balancing the entomological factor against the economical factor.—6-8-40.

Table 1.—Attractiveness of different mixtures of geraniol and eugenol to the Japanese beetle.

Parts by Volume in the Bait		Total Number of Beetles Captured During 6 Weeks		Relative Capture with the Standard = 100*
Geraniol	Eugenol	Test bait	Standard bait	
10	0	3,365	4,333	78
10	1	2,355	2,414	98
10	2	7,548	5,306	142
10	4	7,770	5,306	146
10	8	8,751	5,306	165
0	10	5,235	5,306	99

* Least significant difference with odds of 19:1 is 20.

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Mating Habits of *Scolytus multistriatus* and the Dissemination of *Ceratostomella ulmi*

Collins *et al.* (1936) have shown that mating of *Scolytus multistriatus* (Marsh.) takes place within the brood burrow. An experiment was therefore conducted to determine whether one male *S. multistriatus* visited and perhaps fertilized more than one female and whether in so doing it transmitted the Dutch elm disease fungus *Ceratostomella ulmi* (Schwarz) Buisman to more than one brood burrow.

Forty-one sections of elm branches with the bark intact were placed in battery jars, one section to a jar. These sections, which had been cut from healthy trees and subsequently seasoned indoors for 25 days, ranged from 5 to 9 inches in length and from 2 to 4 inches in diameter. *Scolytus multistriatus* females were reared from elm that was not infected with *Ceratostomella ulmi*. Six females were placed in each jar. Three days later, after they had formed brood burrows, one male was added to each jar. The male had been contaminated with *C. ulmi* by contact with petri plate cultures of the fungus.

Two or 3 weeks later, after larval development had been initiated, the sections were debarked, notes made on the presence of larvae, and the brood burrows removed for culturing. These were cultured by a modification of the method described by Walter (1935).

The results showed that 246 *Scolytus multistriatus* females produced a total of 287 burrows. In fact, 24 elm sections showed 7 or more burrows each and one showed 13.

The data further suggest that one male fertilized more than one female, since 208 of the brood burrows were found to contain larvae. If only 1 female in each jar had been fertilized and had made only 1 brood burrow, there would have been but 41 burrows with larvae, plus a possible additional 7 per cent. Previous work based on 331 females had shown that 7 per cent of them had been fertilized before their removal from the rearing containers. Actually 11 sections contained 7 or more burrows with larvae, and one of these had 11 such burrows.

Of 208 brood burrows with larvae, 165, or 79 per cent, yielded *Ceratostomella ulmi*, whereas of the 79 burrows without larvae, only 20, or 25 per cent, showed the fungus. The data indicate that a single male contaminated with *C. ulmi* may distribute the fungus to several brood burrows as he enters these burrows to mate with the females. There is the possibility, however, that some of the females and perhaps even mites may have become contaminated with the fungus and aided in disseminating it from one brood burrow to another. Regardless of the mode of spread of the fungus in the sections, the only source of inoculum was that originally present on the males.—6-10-40.

CLARENCE H. HOFFMANN, *Bureau of Entomology and Plant Quarantine, and C. S. Moses, Bureau of Plant Industry, U. S. Department of Agriculture.*

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Effect of Insecticidal Residues in Cured Tobacco on Tobacco Moth Larvae

The effect on the development of stored-tobacco insects of residues on tobacco leaves from insecticides applied in the field appears to have been given no consideration in the literature. The insecticides most commonly used on field plants are lead arsenate, paris green, cryolite, and the rotenone-bearing dusts or sprays. Populations of the tobacco moth, *Ephestia elutella* (Hbn.), and the cigarette beetle, *Lasioderma serricorne* (F.), vary greatly within the same hogshead or case of tobacco and in contiguous sections of large tobacco warehouses. Some of these fluctuations may be due to insecticidal residues, and these residues may be an important factor in preventing more serious losses in stored tobacco.

In the late summer and fall of 1938 an outbreak of the tobacco moth occurred in growers' pack houses in certain localities of the flue-cured tobacco growing districts of North Carolina and Virginia. During a survey of this outbreak farmers reported that in bulks of tobacco which had received a late-season application of lead arsenate for the control of hornworms in the field little or no infestation of the tobacco moth developed and in bulks which had not received the lead arsenate treatment prior to harvest the moth developed normally. These reports came from Rockingham County, near Reidsville, N. C.

Samples of flue-cured tobacco were collected in a pack house on one of these farms and brought to the laboratory for the purpose of making feeding tests with tobacco moth larvae. It was reported by the grower that the tobacco had been sprayed with lead arsenate at the rate of 4 pounds to 50 gallons of water and about 50 gallons of the spray per acre. The application had been made with a small compressed-air sprayer a short time before harvest and practically no rainfall had occurred between the date of application and harvest of the tobacco. A sample of the leaves collected in the pack house for the feeding tests was analyzed and found to contain 3.14 grams of arsenic trioxide per pound, or 448 parts per million.[1] For comparison in the feeding tests a sample of flue-cured tobacco, believed to be free of insecticidal residues, was obtained from a re drying plant in Richmond, Va.

Seven leaves of tobacco taken from the pack house near Reidsville were placed in each of five 1-pint fruit jars and 100 eggs of the tobacco moth were added to each. For use as controls five jars were prepared from the tobacco leaves obtained at the re-drying plant. The 10 jars were then placed in the insectary, under conditions satisfactory for development of the moth, and the contents of each jar were examined after 43 days.

On the leaves that had been sprayed, no tobacco moth larvae survived. A total of 36 dead larvae were found and virtually no feeding had occurred.

In the controls much feeding had occurred and a total of 132 living larvae and 33 pupae were found.

Although these data are not extensive, they indicate that insecticidal residues may be a factor in the rate at which the populations of stored-tobacco pests increase on some stored tobaccos.—7-6-40.

J. P. VINZANT and W. D. REED, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

[1] Sample analyzed by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture (I. D. 4145).

Ambrosia Beetle, *Xylosandrus germanus*, Transmits Dutch Elm Disease Under Controlled Conditions[1]

Field observations show that the ambrosia beetle *Xylosandrus germanus* (Bldfd.) may bore into elm logs, felled trees, exposed roots, stumps, and fire-scarred and chemically-killed trees in which the Dutch elm disease fungus, *Ceratostomella ulmi* (Schwarz) Buisman, is present, as well as into simi-

[1] The writer is indebted to C. S. Moses, of the Bureau of Plant Industry, U. S. Department of Agriculture, for providing the cultures of *Ceratostomella ulmi* used to contaminate the beetles and for culturing the beetles and elm material.

lar elm material that is free of the organism. In one instance a beetle was observed boring into an apparently healthy standing elm tree. The above activities may be a means by which this beetle could acquire the fungus from infected sources and then transmit it to noninfected material. Evidence that these beetles occasionally become contaminated in the field is shown by the fact that *C. ulmi* was isolated from 2 of 826 (.24 per cent) adults that were collected in 1936 from the surface of elm trap trees in New Jersey. The following controlled experiments were conducted to determine whether *C. ulmi* might be transmitted by these beetles to uninfected elm logs and trees under conditions favorable for the disease.

In one experiment *Xylosandrus germanus* adults were liberated into a large glass battery jar that contained well-discolored sections from an elm tree infected with the Dutch elm disease. The beetles bored into and backed out from these sections and were then allowed to enter sections from nondiseased trees in a second battery jar. The jars were connected with each other by muslin and celluloid cylinders, through which the beetles moved freely. Chips containing one beetle entrance hole each were cut from the sections in the second jar and cultured for the presence of *Ceratostomella ulmi*. It was found that this fungus was present in 16 of 94 (17 per cent) of the chips. *C. ulmi* was also isolated from 3 of 31 (9.6 per cent) adults of *X. germanus* that were taken directly from the diseased sections into which they had bored.

In a second experiment six healthy elm trees were enclosed in muslin cages. These trees were of 5-year-old nursery stock and had been transplanted into butter tubs 2 years previously. *Xylosandrus germanus* adults that had been contaminated with *Ceratostomella ulmi* by allowing them to walk over petri-plate cultures of the fungus were liberated on the caged trees, an average of 250 adults per tree. These beetles made on an average 11.3 holes per tree, all of which were in the trunks. Most of the holes were concentrated in the basal areas of the trunks where the bottom of each cage was tied. *C. ulmi* was isolated later from five of the six trees. However, typical external symptoms of the Dutch elm disease developed in only one of them. In the other trees the fungus was present only in the tissue adjacent to the holes that were made by the infected beetles.—6-22-40.

W. D. BUCHANAN, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

OBITUARY

Esther Hastings Hart

Miss Esther Hart, entomological delineator in the Federal Bureau of Entomology for more than 20 years, died in Washington, D. C., on August 3, after a long illness.

Esther Hastings Hart

Miss Hart was born on February 22, 1862 at Elmira, New York. She obtained an A.B. degree at Elmira college and, later, studied art and wood engraving at Cooper Institute, being a fellow student with Anna Botsford Comstock while here.

In 1906 Miss Hart secured employment in the Patent Office as a draftsman and in 1907 she was transferred to the Forest Service for similar work. While she was thus employed her drawings of insects attracted the attention of Dr. A. D. Hopkins who secured her transfer to the Bureau of Entomology, in 1911, for similar work, especially for the delineation of forest insects.

Among the many drawings made by Miss Hart may be mentioned those in Dr. Craighead's monograph of the North American Cerambycid Larvae.

When, in 1917, the writer was compelled to lay aside his pencil in entomological delineation, Miss Hart was transferred to the division of Cereal and Forest Insect Investigations. Here, during a period of about 15 years she illustrated many of the technical and popular publications of the Division and many of her drawings have seldom been excelled either for technique or delineation of habitus.

Her accomplishments form a memorial to the ability of Miss Hart far more enduring and eloquent than mere words since excellent illustrations have a way of perpetuating themselves long after their authors have disappeared from human recollection.

Continued ill health forced Miss Hart to retire from active work in 1932.

Aside from her artistic accomplishments, the writer and other members of the staff of the Bureau, long associated with Miss Hart will remember her as a woman of kindly, refined and lovely character.

W. R. WALTON

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Entomology and Preparedness

ENTOMOLOGISTS, especially those engaged in the economic phases of their subject, must be concerned with the part which they must play in the imminent program for assuring the safety of the nation.

The country as a whole has come to the realization of the fact that, although we are not at war with any nation we are most deeply involved in the war. Should we be drawn into actual warfare the problems of the entomologist, as of all citizens, will be intensified but will scarcely differ in kind from those with which he is concerned during the period of preparation.

Long before Napoleon formulated the statement which has become a classic among quotations, that "An army marches on its stomach" military leaders had learned that the most vital essential in a program of either offense or defense was the food supply. While we have, for a period of years, been living in a land of plenty, with foodstuffs to burn, literally, and while current crops and the existing surplus seem now to be adequate, we must not assume that this condition is bound to continue.

Should we succeed in remaining out of the war, or should an early peace be concluded, we are still bound to expect that we shall have to feed a large part of a semi-starved European population for a time. This may cause an immediate drain on our surplus. If we could count on normal seasons and normal insect populations, we might confidently expect to care for the demands which would be made upon our agriculture.

However, agriculture is a hazardous pursuit; we can not know, from year to year, what our production will be. Should we be faced with unusual demands, domestic or foreign, and, at the same time, encounter some of the lean years which we have known in the past, a serious shortage might develop and in such shortage, insect injury might well be, as it has been in other years, the deciding factor.

Entomologists should, for this reason, so plan their programs as to give, or to be able to give promptly, immediate assistance in the suppression of threatened outbreaks of insects, especially those which attack the staple crops, in the field or in the granary. Especially should we arrange to strengthen our extension program to the degree that necessary information may not be merely offered to the producer but shall be actually forced upon him, with a sufficient follow-up program to see that the producer utilizes the information in a proper manner.

To do this we must conserve our manpower. The program of military training for young men, and others, is under way. We may expect that some entomologists will be called, due to their affiliation with the organized reserve forces; others may properly be taken to assist in the sanitary program which the establishment of military camps will necessitate. Here, we should cooperate without reserve, since past experience has shown that no more important service can be rendered than the control of the insects which may engender disease, especially in large assemblages of men living in somewhat unusual if not abnormal conditions.

On the other hand, some exemptions should be allowed to entomological workers who are doing work of an experimental nature, work which they can do better than any substitutes could be expected to do, and work which may have a direct bearing on maintaining the necessary food reserve.

What will be the policy of those charged with the selection of men for military training. Upon what basis will they establish exemptions? Undoubtedly the answer to this, so far as it may affect entomologists, depends to a degree upon the entomologists themselves. If they can establish, to the satisfaction of the authorities, the essential nature of the work in which they are engaged, proper exemptions may be expected.

A general discussion of this topic might well find a place in the program for the approaching annual meeting of the *Association*.

REVIEWS

Important Tree Pests of the Northeast, pages 1–187. Published by the Massachusetts Forest and Park Association, 1940.

This book is a revision, with indexes, of fifty well illustrated Tree Pest Leaflets published by this association in 1936–1940 under the direction of a representative committee and through the cooperation of well recognized experts in their respective specialties. The leaflets deal with such important troubles as the European spruce sawfly, the gipsy moth, the spruce bud worm, forest and shade tree aphids, black spot fungus of elm, cedar apple rust, Nectria canker of hard woods, Dutch elm disease, shoe-string rot of conifers and hard woods, to list a few of the more important leaflets.

The sponsors have rendered a distinct service to shade tree and forest conservation by issuing this matter in such a convenient indexed volume at the nominal price of $1.00. The wide range of subjects makes the book most useful to all concerned with tree welfare.

E. P. Felt

Insect Transmission of Plant Diseases by Julian Gilbert Leach. Pages i–xviii, 1–615, 238 text illustrations. McGraw-Hill Book Company, New York and London, 1940.

The transmission of plant diseases by insects has been known for many years yet few have an adequate idea of the extent of this and its economic significance.

This work is a well illustrated, comprehensive digest of a comparatively unknown subject which has been greatly illuminated by the investigations of the author. There is a preliminary discussion of plant pathology, its origin and growth, with special reference to the part played by insects in the transmission of various organisms.

The second chapter presents in some detail the inter-relationships of plants and insects with special reference to the evolutionary aspects. The discussion and definition of symbiosis in its varying aspects in relation to insects and microorganisms establishes an excellent basis for the detailed accounts in subsequent parts of the book. There is a historical presentation of the relation of insects to the spread and development of plant diseases in chapter 4. The author distinguishes in this work between the effects produced by toxic secretions of insects and the results following inoculation by bacterial, fungous or virus diseases. He recognizes species which transmit parasitic microorganisms, others which produce wounds permitting infection and a third group which transmits parasitic microorganisms internally and may cause either mechanical internal transmission or biological internal transmission.

One chapter is devoted to insects and bacterial diseases, another to insects and fungous diseases, and two others to insects and virus diseases, these being general considerations which are followed by chapters on insects and phytopathogenic Protozoa, mites, nematodes, and other small animals as vectors, the anatomy and physiology of plants and of insects in relation to the transmission of plant diseases, the inocula of plant pathogens in relation to insect transmission, and the feeding and breeding habits of insects in connection with the transmission of plant diseases. There is a chapter presenting a comparison with insect transmission of animal diseases, and a final one devoted to methods useful in the study of insect transmission of plant diseases.

The reader will be impressed by the comprehensiveness of the book and find much of value in the accounts of numerous virus, bacterial and fungous diseases occurring in different parts of the world and transmitted to a greater or less extent through the agency of insects. The scope of the volume is suggested by a partial list of the diseases treated, namely: Psylid yellows of potato, aster yellows, bean mosaic, peach mosaic, pineapple yellow spot, raspberry leaf curl, tobacco mosaic, bacterial wilts of willow, corn, cucurbits, fire blight of pear and apple, olive knot, blackleg of cabbage, blue stains of coniferous trees, chestnut blight, sooty mold of orange, and Dutch elm disease.

This book with its comprehensive bibliographies affords a ready guide for much needed investigations in relation to this subject and emphasizes in a convincing manner the need of closer cooperation between pathologist and entomologist and the more general recognition that an important factor in the control of diseases may be found, in certain cases at least, in the control of the insect carriers.

E. P. Felt

Horticultural Inspection Notes

The Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture has authorized a method of treatment, under supervision, of certain fruits and vegetables with methyl bromide as a condition of certification for their movement from Hawaii to the mainland under the quarantine relating to the Mediterranean fruitfly and the melonfly. Extensive experiments by the Bureau have demonstrated that the fumigation of guavas, papayas, bell peppers, bitter melons, cucumbers, summer squash, string beans, and tomatoes with methyl bromide under prescribed temperature, dosage and exposure conditions, will kill all stages of the life cycles of both these flies. Notice of such authorization was given in circular B. E. P. Q. 510, effective August 1, 1940.

Federal quarantine regulations relating to the white-fringed beetle have been further modified to lift all restrictions on the movement from any part of the regulated area of baled cotton lint and linters, and also on cottonseed when free from gin trash. Sanitation practices at the cotton gins are required to be maintained. This modification was made effective August 9, 1940 by a revision of circular B. E. P. Q. 485.

A revision of California quarantine proclamation No. 9 pertaining to the sweetpotato weevil, which became effective on July 22, 1940, adds to the infested area the Louisiana parishes of Vernon, Rapides and Avoyelles, and the Mississippi county of Covington and eliminates from the infested area certain Texas counties which have been found by Federal-State survey to be weevil free and from which restricted products are admissible under certification.

The Alabama State Legislature passed an act on July 10, 1940, which provides that reciprocal agreements may be entered into between the Alabama Department of Agriculture and Industries and similar departments of other States whereby the out-of-State inspection certificate or permit may be granted to nurserymen and dealers without the payment of a fee and providing that the other States require inspections equal to those required under the Alabama law.

CURRENT NOTES

Eastern Branch To Meet at Atlantic City

The annual meeting of the Eastern Branch of the Association will be held in Atlantic City, New Jersey, on November 14 and 15, 1940. Hotel headquarters will be at the President.

A symposium on plot technique and statistical methods is to be a special feature of the program to supplement the paper-reading sessions.

Officers for the 1940 meetings are Wm. H. White, Chairman; J. L. Horsfall, Vice-Chairman and Harry B. Weiss, Secretary-Treasurer.

Natural Resources Building at Urbana To Be Dedicated

Dedication of the five-story Natural Resources Building on the University of Illinois campus, Urbana, Illinois, is scheduled for the afternoon of November 15. The building, which with its laboratory equipment represents an outlay of approximately $800,000, is occupied jointly by the Illinois Natural History Survey and the Illinois Geological Survey.

Of special interest to entomologists are the large insect collection room with its tiers of metal cases, a constant temperature room for insect control work, a compounding room for insecticides, a series of laboratories especially equipped for various entomological investigations and a large greenhouse south of the new building in which insect pests of flowers and other greenhouse crops are being studied.

The dedication ceremony of the building will come as a high point in two conferences in progress November 14, 15, and 16. The sixth annual Midwest Wildlife Conference, sponsored by the Illinois Natural History Survey, will draw wildlife technicians, many of them concerned directly or indirectly with entomological problems, from Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. Mineral industries groups will meet under the sponsorship of the Illinois Geological Survey.

Dr. T. H. Frison, Chief of the Natural History Survey, has issued a general invitation to entomologists interested in wildlife problems to attend the three-day meeting of the Midwest Wildlife Conference. The occasion of the dedication, to which entomologists are invited, presents a unique occasion for inspecting the new building and for meeting other scientists from various parts of the United States.

The entomological work of the Natural History Survey represents the oldest continuous line of activity of this state organization, dating from the establishment of the office of State Entomologist in 1867.

Cotton States Branch To Meet with Texas Entomological Society at Waco

The Texas Entomological Society will act as host to the Cotton States Branch of the American Association of Economic Entomologists, during the 1941 annual meetings of these two organizations. These meetings will be held in the city of Waco, Texas. The convention hotel has not been selected.

The officers of the Texas Entomological Society are: Dr. Roy M. Melvin, President, Minard, Texas; Dr. L. F. Curl, Secretary, San Antonio, Texas. These officers will serve as the Committee on Arrangements.

The officers of the Cotton States Branch are: Dr. Z. P. Metcalf, Chairman, Raleigh, North Carolina; Dr. F. A. Fenton, Vice-chairman, Stillwater, Oklahoma; Dr. John T. Creighton, Secretary and Treasurer, Gainesville, Florida.

Cumberland-Shenandoah Fruit Conference

The Cumberland-Shenandoah Fruit Conference will be held at Martinsburg, West Virginia, on November 22 and 23. Headquarters will be in the Hotel Shenandoah.

The afternoon of the 22d will be devoted to a visit to the West Virginia University Experiment Farms at Kearneysville and to experimental work in progress in the vicinity.

A general conference will be held at 7.30 P.M. and this will be followed on the morning of the 23d by group conferences. The entire group will convene again at luncheon, the final business session being held in connection with the luncheon.

Regular participants in this conference include entomologists, plant pathologists and horticulturists from the United States Department of Agriculture and from the states of Maryland, Pennsylvania, Virginia and West Virginia. Visitors are cordially invited to attend and participate in the discussions. The program is entirely informal.

The Chairman of the meeting is Edwin Gould and the Secretary is Carlton F. Taylor, both from the West Virginia Agricultural Experiment Station.

PROCEEDINGS OF THE FOURTEENTH ANNUAL MEETING
COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Bankhead Hotel, Birmingham, Alabama, February 7–9, 1940

The Fifteenth Annual Meeting of The Cotton States Branch of The American Association of Economic Entomologists was held in Birmingham, Alabama, on February 7, 8 and 9, 1940. The meeting was held in conjunction with the annual meeting of The Association of Southern Agricultural Workers. The attendance was very disappointing. Only sixty-two signed the attendance roll as contrasted with 166 at the Fourteenth Annual Meeting in Tampa, Florida, in 1939.

The fifteenth annual convention was in the nature of a celebration of the Fifteenth Anniversary of the Cotton States Entomologists affiliation as a Branch with the American Association of Economic Entomologists. The programs carried out the spirit of the occasion by inluding a picture of the 1939–1940 chairman on the cover, pictures of past chairmen on the inside of the cover, and a plate of the boll-weevil on back. Chairman Oliver I. Snapp's address on "The History of The Cotton States Branch," was the highlight of the meeting. Mr. Snapp demonstrated an exceptional knowledge of the background of The Cotton States organization and his presentation was stimulating to all in attendance.

Attending entomologists were guests at the annual banquet of The Association of Southern Agricultural Workers on Wednesday evening, February 7, and at the Cotton Ball on Thursday evening, February 8. The latter was sponsored by the southern home-demonstration agents.

Dr. Harry S. Smith of Riverside, California, President of the American Association of Economic Entomologists, was in attendance. Dr. Smith brought greetings from the parent organization and discussed the great contributions of the South and southern entomologists to the advancement of the science.

A special entomologists' luncheon was enjoyed on Friday, March 9. This was arranged by the local committee, which consisted of J. M. Robinson, Chairman, H. C. Young, F. E. Guyton, and L. L. English.

Twenty-seven papers were presented. These included discussions of pests of cotton, livestock, greenhouse plants, and vegetables. Papers were also presented dealing with university and college pest control problems, extension problems, student insect mounting, and an introduced parasite of the sugar cane borer.

Business Proceedings. The first business session was called to order at 1:00 P.M., Thursday, February 8. Chairman Oliver I. Snapp was presiding. The following were present:

H. S. Adair	J. P. Kislanko
Norman Allen	J. M. Langston
F. S. Arant	N. Lawson, Jr.
H. M. Barre	Horace Lee
W. D. Beck	E. R. Lett
G. M. Bentley	B. P. Livingston
Theo. L. Bissell	E. M. Livingstone
G. L. Bond	U. C. Loftin
F. F. Bondy	Clay Lyle
T. F. Bridges	Z. P. Metcalf
O. L. Cartwright	Jack Milton
R. S. Cathcart	Milledge Murphy
R. C. Collins	J. Fred O'Kelley
R. P. Colmer	N. D. Peets
John T. Creighton	C. F. Rainwater
N. L. Douglas	J. M. Robinson
E. W. Dunnan	H. F. Sessums
A. L. Dugas	F. A. Smith
L. L. English	Harry S. Smith
Alfred Fenton	Oliver I. Snapp
J. C. Gaines	W. H. Tisdale
R. C. Gaines	S. J. Vann
J. S. M. Gaulin	J. G. Watts
Orvis B. Griggs	G. M. Weber
M. L. Grimes	G. J. Wilds
A. L. Hamner	J. Robins Wood
A. J. Hettesheimer	M. S. Yeomans
Conrad Johnson	H. C. Young
M. P. Jones	M. T. Young

Chairman Snapp called for a report of the Secretary-Treasurer. The report was as follows:

REPORT OF THE SECRETARY-TREASURER

The number of members in the Cotton States Branch on December 31, 1938, was 191. On January 3, 1940, there were 261. There has been a total increase in membership of 83. Thirteen members either moved out of the Branch territory or were

dropped by the parent association, resulting in a net increase of 70.

The number of members by states on January 3, 1940, was as follows: Texas, 87; Florida, 44; Louisiana, 37; Mississippi, 25; North Carolina, 15; South Carolina, 13; Alabama, 13; Georgia, 12; Oklahoma, 7; Arkansas, 5; Tennessee, 3. The following states showed net increases during the period: Texas, 40; Florida, 13; Louisiana, 7; Mississippi, 4; North Carolina, 3; South Carolina, 1; Alabama, 8. Net decreases during the period were as follows: Arkansas, 1; Georgia, 2; Tennessee, 2.

Annual dues in the Cotton States Branch are $1.00. All members of the American Association of Economic Entomologists that reside in the Cotton States Branch territory are automatic members of the Branch. Dues are now payable. The registration fee for this convention is credited as annual dues for the year, 1940.

The employment of secretarial help as voted at the final business session of the Fourteenth Annual Meeting has not been done because the secretary did not feel that the Branch was in a financial condition that would permit it.

FINANCIAL STATEMENT

FUNDS RECEIVED

Feb. 25, 1939. Amount on hand	$114.98
Mar. 27. Checking account—Transferred Fort Valley, Ga., to Gainesville, Fla.	63.48
Apr. 12. Received from Secretary Ernest Cory, American Association of Economic Entomologists	52.05
Feb. 20–24. Registration fees at Tampa, Fla., contributions 31 persons @$1.00 each	31.00
Feb. 26. Dues paid	86.00
Jan. 19, 1940. Interest	1.71
Total	$349.22

EXPENDITURES:

Miscellaneous items	$142.46
Balance on hand February 3, 1940	$206.76

JOHN T. CREIGHTON
Secretary-Treasurer

Gainesville, Florida
February 3, 1940.

The following special committees were appointed:

1. NOMINATIONS: Clay Lyle, Chairman
   J. M. Robinson
   G. M. Bentley
2. RESOLUTIONS: J. M. Robinson, Chairman
   R. C. Gaines
   A. L. Hamner
3. AUDITING: E. W. Dunnam, Chairman
   R. P. Colmer
   Theo. L. Bissell

FINAL BUSINESS SESSION

Chairman Oliver I. Snapp called for the report of appointed committees.

The Auditing Committee's report follows:

The Auditing Committee met and inspected the financial report of the Secretary-Treasurer, Dr. John T. Creighton, and found it to be correct in every detail.

In behalf of Association members, the Committee wishes to express its deep appreciation for the splendid progress made in the membership drive, which resulted in a substantial increase in finances.

Therefore, the Committee recommends that the report be accepted as presented.

Respectfully submitted, E. W. DUNNAN, R. P COLMER, THEO. L. BISSELL.

A discussion was held relative to the selection of a 1941 convention city. The following motions were made: That the Cotton States Branch held the 1941 meeting in the State of Texas and that the selection of a convention city be left to the executive committee; but that this committee be instructed to work with the executive committee of the Texas Entomological Society in an effort to hold the meeting at the same time and place as the annual meeting of that organization.

The attention of the membership was called to congressional action relative to appropriations for the pink bollworm and white fringed beetle quarantine and control programs. After careful discussion a motion was made and adopted which instructed the Secretary-Treasurer to dispatch appropriate messages to the President of the United States and to Senator Richard B. Russell of the Committee on Agricultural Appropriations.

The membership recognized the factors contributing to the small attendance and subsequently special resolutions designed to make possible an increased attendance.

The regular report of the Resolutions Committee included the usual resolutions of appreciation and the following:

Be it further resolved that we pause to note the passing of two of our younger members, namely, Dr. L. O. Ellisor and Dr. B. A. Osterberger, of the Louisiana Agricultural Experiment Station staff.

Resolutions Committee, A. L. HAMNER, R. C. GAINES, J. M. ROBINSON.

When the resolution pertaining to the passing of Dr. L. O. Ellisor and Dr. B. A. Osterberger was read, the membership rose in silent tribute to these fellow workers.

The Nominations Committee recommended the following officers for the year 1939–1940, and they were duly elected:

Z. P. METCALF, Raleigh, N. C., Chairman
F. A. FENTON, Stillwater, Oklahoma, Vice-Chairman
JOHN T. CREIGHTON, Gainesville, Florida, Secretary-Treasurer

Past Chairmen J. M. Robinson and Clay Lyle escorted the new chairman to the place of honor. The new chairman, Z. P. Metcalf, took over the gavel at 12.27. He made a few brief announcements relative to the 1941 meetings and final adjournment was proclaimed shortly thereafter.

JOHN T. CREIGHTON
Secretary-Treasurer

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